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MEGA-PROJECT CONSTRUCTION MANAGEMENT: THE CORPS OF ENGINEERS
AND BECHTEL GROUP IN SAUDI ARABIA

by

Jeffrey Craig Smith

B.S., United States Military Academy
(1980)

Submitted to the Department of
Civil Engineering in Partial Fulfillment of
the Requirements for the
Degree of

MASTER OF SCIENCE
in Civil Engineering

at the

Massachusetts Institute of Technology

February 1991

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ABSTRACT

facility that was
The purpose of this thesis *seeks* to develop empirical hypotheses for the successful construction management of international mega-projects through a multiple exploratory case study methodology.

The case study involves two massive construction programs recently completed in Saudi Arabia by American engineering/construction firms. The first is a \$6 billion military city constructed for the Saudi Arabian Army by the US Army Corps of Engineers at Al Batin from 1976 -1987. The second is a \$20 billion industrial port city constructed by Bechtel Group at Jubail from 1976 - Present. The projects are analyzed separately then compared in the areas of planning, organization, staffing and control. The comparison also highlights differences between public and private sector approaches to mega-project management.

→ The thesis identifies the unique challenges of international mega-projects and develops hypotheses for maximizing construction management performance while minimizing management costs and contract disputes.

The study establishes 10 hypotheses, for effective international mega-project management. They encompass: specific organizational forms; staff locations; personnel policies; management cost control; contract types; controlling international contractors; minimizing disputes; Life Cycle Project Management; owner provided equipment, materials and services; and infrastructure development to support project construction.

Thesis Supervisor: Professor Fred Moavenzadeh

Title: Professor of Civil Engineering
Director, Center for Construction
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BIOGRAPHICAL NOTE

The author is an active duty Captain commissioned in the US Army Corps of Engineers. He is the son of a career Air Force pilot and was born at Tachikawa Air Force Base, Japan in 1958. He attended the United States Military Academy at West Point, New York from 1976 - 1980, receiving a Bachelor of Science Degree with a concentration in Civil Engineering.

He has served with engineer troop units at Fort Carson, Colorado, Camp Carroll, Korea and Fort Devens, Massachusetts. In addition, he spent 18 months at Taif, Saudi Arabia with the US Army Corps of Engineers' Middle East Division constructing support facilities for the Royal Saudi Air Force.

He is a graduate of the Army's Engineer Officer Basic and Advanced Courses and the Combined Arms Services Staff School. He is a Registered Professional Engineer in Virginia and is a member of the Society of American Military Engineers.

He is married to the former Laura Jean Mills and has a daughter, Amanda, born in 1987.

DEDICATION

I dedicate this thesis to my wife, Laura and daughter, Amanda. Their love and support made this entire effort worthwhile.

A special dedication goes to Laura's father, the late Jim Fred Mills, a man who devoted his life to his family and community.

ACKNOWLEDGMENTS

I obtained a large amount of information for this thesis from several individuals who freely assisted me without expectation of personal gain. Some of the most helpful were:

Dr. Paul Walker	Historian Center of History, USACE
Mr. Dale Floyd	Reference Historian Center of History, USACE
Mr. Joseph Anderson	Senior Vice President Bechtel Corporation
LTC (Retired) John N. Vanderschaaf	Deputy Program Manager Saudi Arabian Bechtel Company

I would like to thank several people who helped and supported me during my studies:

Fred Blanchard, who took considerable time out of his own PhD and teaching schedule to be my primary advisor. He reviewed my work at great depth and pointed me in the right direction.

Professor Fred Moavenzadeh, who provided excellent ideas on a moment's notice.

I thank my Army buddies, Alex Dornstauber, Bill Graves, Mark Johnson and John Piatak for providing an effective sounding board for ideas and complaints.

Most of all, I'd like to thank my father and mother, Colonel (USAF, Retired) Kendall and Lorraine Smith for their lifelong patience, guidance, inspiration and support.

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CHAPTER 1 - INTRODUCTION

As mankind approaches the 21st Century, international mega-projects are likely to become increasingly common in the engineering and construction industry. Participants at the Engineering Foundation Research Conference defined a mega-project as a high impact technically complex project which requires careful advanced planning, lasts three or more years, has a significant impact on the public and industry, employs thousands of people and typically costs over \$1 billion./1 The reasons for projecting an increase in the need for mega-projects are:

1. Deterioration and deficiencies of existing infrastructure, particularly highways, bridges, water and sewage treatment plants.
2. Massive infrastructure required in third world countries to improve their economies.
3. Accumulation and impact of hazardous wastes on the environment.
4. Continuing need for aggressive private development and huge industrial projects.

The very nature of these needs implies that fulfilling them falls within the definition of a mega-project. It is essential that both proponents and implementers of mega-projects fully understand the factors involved in their planning, execution and overall management.

1.1 PURPOSE AND MOTIVATION FOR RESEARCH

Since the growth of large scale construction projects is increasingly probable, now is an opportune time to examine whether construction managers can afford a "business as usual" approach to mega-project management. My purpose for researching this topic is to develop an understanding of the challenges unique to mega-projects, particularly international mega-projects, and to identify universal construction management techniques to meet them.

The U.S. Army Corps of Engineers is the nation's largest buyer of constructed facilities and an organization with worldwide mega-project management experience. It has a well developed organizational structure, standing operating procedures for construction management, primary responsibility for the nation's waterways and wetlands and diplomatic duties in performing military construction for friendly foreign nations. The Corps has a well documented track record in mega-project management. Therefore, its performance on international mega-projects is relevant to developing hypotheses of management techniques which should be applied to these types of projects.

The Corps' experience represents a useful source of construction management information. However, as a public agency, it operates under limitations imposed by the government and has different motives than private companies do. Therefore, it is also appropriate to examine the private sector for international mega-project management innovations.

Bechtel Group, Incorporated, with a sixty year record of mega-project management, provides a construction management perspective from the private sector. An informal listing of some of the similarities and differences in motivations, objectives and constraints of the two approaches helps illustrate the need to analyze both sectors of the industry.

FACTOR	USACE (PUBLIC)	BECHTEL (PRIVATE)
Primary Motive for Existence	Public Service	Business Profit
Secondary Motive	Maintain Reputation as World-Class Engineering/Const Contractor	Maintain Reputation as World-Class Engineering/ Const Contractor
Objectives	Respond to Changing Public Needs	Grow & Remain Profitable
	Control US Waterway Use & Development	Be Preeminent US Contractor in Target Markets
	Be Effective Arm of Gov't for Foreign Diplomacy	Be Competitive in Foreign Target Markets
Constraints	Must Follow Defense Acquisition Regs	Competition From Other Firms in the International Marketplace
	Cannot Compete with Private Firms for Work	Conformance With US Laws Not Applied to Foreign Firms on International Work
	Manning Level & Appropriations Set by Congress	Terms of Contracts With Clients
	Terms of Agreements With Foreign Governments	

Although USACE and Bechtel often perform similar functions for their clients, it is clear that they often do them for

different reasons. Thus, the construction management efforts of each firm should be evaluated in the context of its unique motivations, objectives and restrictions. The combination of public and private sector philosophies of international mega-project management forms the basis of this project.

1.2 STATEMENT OF PROBLEM AND RESEARCH OBJECTIVES

The central problem and focus of this thesis is to determine techniques international construction managers can use to effectively plan, organize, staff and control international mega-projects. The following are specific questions addressed in this thesis:

1. What organizational forms are effective for a construction manager to use in international mega-projects? At what levels within the organization should responsibilities and authority be assigned?
2. What personnel policies can be used to attract the right people with the right skills to the project at the right time, and to support them during demobilization?
3. What are the logical physical locations for the construction management staff?
4. How can construction managers adequately staff projects while controlling management costs?
5. What construction contract types are the most appropriate for use in international mega-projects?
6. What special management techniques are effective for controlling international contractors?
7. How can construction managers minimize contract disputes?
8. Does a Life Cycle Project Management philosophy apply to mega-projects?
9. How many construction support services should construction managers provide their contractors?
10. How do construction managers plan for infrastructure development in conjunction with completing mega-projects?

With these problems in mind, specific research objectives are:

1. To study construction management techniques used in recent public and private international mega-projects to determine whether they were appropriate

for the mega-projects' unique challenges.

2. To develop an empirical hypothesis of a suitable approach to construction management of future international mega-projects.

1.3 RESEARCH METHODOLOGY

To develop this thesis, I chose a multiple exploratory case study methodology. The cases are of two mega-projects performed in Saudi Arabia during the late 1970s through the mid-1980s. They are similar in scope and magnitude except that the construction manager of one was a public firm (U.S. Army Corps of Engineers) and the other a private firm (Bechtel Group). First, I analyze and critique each case separately within the context of the challenges faced by the construction manager. Then, I compare and contrast the techniques used by each construction manager across the two cases. Third, I synthesize international mega-project management techniques from the comparison/contrast of the cases. Finally, I summarize the techniques to develop conclusions and make specific recommendations regarding international mega-project management.

1.3.1 CASE STUDY JUSTIFICATION

This thesis requires a novel research design for analyzing the construction management techniques used by the US Army Corps of Engineers and Bechtel Group in their Saudi Arabian mega-projects. The research design must facilitate the determination of management techniques from the analyses which should be successful if repeated on future international mega-projects.

A valid statistical comparison of construction management is almost impossible to make because construction

management, by its very nature, represents more of an art than a science. Each project is unique in design, materials used and built upon, and in environmental conditions under which constructed. When one adds to this the unique aspects of international mega-projects such as nonhomogeneous labor, management and equipment, varying infrastructure and diverse governmental policies, most forms of empirical analysis become invalid.

The most appropriate research design for this thesis is the case study. A case study's structure, by definition, best fits the objectives of this thesis without ignoring the significant variables encountered in international mega-projects:

"Case studies, like experiments, are generalizable to theoretical propositions and not to populations or universes...the investigator's goal is to expand and generalize theories (analytic generalization) and not to enumerate frequencies (statistical generalization)."/2

Thus, the case study's design facilitates "hypothesis-generating" through an empirical inquiry that investigates the management of contemporary construction projects within their real-life contexts where the boundaries between the management techniques and context are not clearly evident and multiple sources of evidence are available./3

Perhaps more importantly, the case study is an excellent way to examine the universal challenges construction managers face in any project. These similarities are the need for proper planning, organizing, staffing and control of the project. Case studies facilitate the application of

management theories to examine problems encountered in individual mega-projects. They allow the investigator to isolate similarities in different cases for study without ignoring variations in the case environments. Finally, multiple case studies form the basis from which to compare the effectiveness of different management techniques addressing common challenges. New management theories can then be distilled (or old theories supported) from the case comparisons.

1.3.2 CASE STUDY DESIGN

According to Yin, the critical components of an exploratory case study's research design are:

1. The study's questions.
2. The study's unit(s) of analysis.
3. The logic linking the data to the questions.
4. The criteria for interpreting the findings./4

The first component has already been described in Section 1.2. The second component involves defining what the case is. For the purposes of this study there are two primary cases. One is the Corps of Engineers' management of the construction of King Khalid Military City. The other is Bechtel's management of the construction of an industrial port and city at Jubail. However, several subunits are useful in developing the primary units' analyses. Some examples of subunits whose analyses contribute to the overall study are; specific functional areas of USACE and Bechtel, performance on individual contracts and facilities, and management decisions affecting portions of the work. In

every instance, subunit analysis relates to the comprehensive analysis of the primary units. The ultimate result is a multiple, embedded case study design involving a comparison/contrast of construction management across the cases./5

I intend, in the research design, to link data to the study's questions through a pattern-matching technique called "hypothesis-generating"./6 My goal is to analyze the case study data by making critical insights into large scale international construction management and building a series of hypotheses about the cases. The hypotheses derived from the case study lead to the development of recommendations for future construction management policies.

Since the data in this case study doesn't lend itself to statistical evaluation, it requires a narrative criterion for interpreting the study's findings. In order to accomplish the final component of research design the study compares rival hypotheses, where possible, and interprets the findings. In addition, it compares and contrasts findings from the individual case analyses across the cases to ensure proper evaluation of the case study data.

1.3.3 TESTING CASE STUDY DESIGN

The case study design passes the three tests of validity that Yin established for exploratory studies. The tests are:

- **Construct Validity:** Establishing correct operational measures for the concepts being studied.
- **External Validity:** Establishing the domain to which a study's findings can be generalized.

- **Reliability:** Demonstrating that the operations of a study can be repeated, with the same results./7

My primary strategies to ensure Construct Validity are the use of multiple sources of evidence to encourage convergent lines of inquiry and the establishment of a chain of evidence. I collected case study data using four of the six normally accepted sources of evidence:

<u>EVIDENCE SOURCE USED</u>	<u>KKMC</u>	<u>JUBAIL</u>
Documentation	Yes	Yes
Archival Records	Yes	Yes
Interviews	Yes	Yes
Direct Observation	Yes	No
Participant Observation	No	No
Physical Artifacts	No	No

Sources of documentation used in this case study include letters, memoranda, meeting minutes, proposals, formal studies and articles from mass media and trade publications. Archival records sourced include organizational charts, budgets, maps, survey data and project lists. Interviews came from key personnel from USACE, Bechtel and some of the contractors involved in the projects. I also made some direct observations from site visits to KKMC in 1983 and 1984.

To enhance construct validity, I obtained copies of virtually all evidence used in my analysis of the cases. The evidence was then carefully reviewed, cataloged, cited and filed for future review. The use of multiple sources of evidence enhances the validity of the multiple case study research design selected for this thesis.

In order to pass the second test of exploratory case

study design, External Validity, I strove to generalize the results of data analysis for the KKMC and Jubail projects to broader hypotheses which apply to the each case. Thus, as in the process of experimentation, the hypotheses posed gain credibility through replication logic and can be applied with more confidence to future international mega-project management.

In this case study's design the third test, Reliability, is tied inextricably to the Construct Validity test. The Reliability test's objective is to ensure that if another investigator performs a study of the same case he will arrive at the same findings and conclusions. To that end, the quantity, quality and availability of the data base to inspection are imperative. Establishing a diverse data base for this case study and carefully cataloging it to meet the Construct Validity test criterion also goes a long way toward satisfying the Reliability test criterion. In addition, I attempt to enhance reliability by testing conflicting hypotheses across the cases to make reasoned, rather than impassioned, findings and conclusions.

In summary, the design selected for this case study passes the tests established for validating exploratory case study designs. I assert that the design supports the study's findings, conclusions and recommendations.

1.4 THESIS ORGANIZATION AND SCOPE

In the next chapter, I provide general background information necessary for complete understanding of the case analyses. I discuss the growth of international mega-projects and specifically highlight their importance in the Kingdom of Saudi Arabia's development plan. Later in the chapter I describe the U.S. Army Corps of Engineers' historical construction management role and identify how it became involved in assisting the Saudis. I also provide a similar background description of Bechtel Group and describe how it became involved in the Kingdom's development program. Finally, I review the current theory of construction management techniques for mega-projects in the areas of organization, contract types and authority, dispute resolution and Owner Furnished Equipment.

In Chapter 3, I perform a case study of the Corps of Engineers' management of the construction of an entire Saudi military base. The King Khalid Military City (KKMC) is a \$6 billion divisional army installation designed and constructed under USACE management in the desert near the Iraqi border. The chapter includes a case background as well as the complete analysis of USACE's performance as the construction manager.

Chapter 4 is the case study of Bechtel Group's \$10 billion construction of an industrial port and city at Jubail, on the Persian (Arabian) Gulf. Although it is a separate case study from Chapter 3's, wherever possible I

analyze Bechtel's performance in the same areas of construction management.

In Chapter 5, I compare and contrast the techniques of the two construction managers across the cases, noting similarities, differences, strengths and weaknesses of their approaches.

Finally, in Chapter 6, I complete the analyses of the two cases by developing hypotheses for successful management of international mega-projects. I conclude which hypotheses can be generalized to other mega-projects and make recommendations for their adoption within the industry. I also identify the limitations of my research efforts and recommend areas of further research into international mega-project management.

CHAPTER ENDNOTES

1. Engineering Foundation Research Conference, Planning, Engineering and Constructing the Superprojects (New York: ASCE, 30 Apr-5 May 1978), p. 395.
2. Robert K. Yin, Case Study Research: Design and Methods, (Beverly Hills: Sage Publications, 1984), p. 21.
3. Adapted from Yin's definition of a case study. Ibid., p. 23.
4. Ibid., P. 29.
5. Yin gives a complete discussion of multiple, embedded case design in Chapter 2. Ibid., pp. 41-53.
6. Yin mentions the "hypothesis-generating process" as an outgrowth of the explanation-building analytic strategy and which is applied to exploratory case studies, only. Ibid., p. 107.
7. These are identical to the four tests that Yin proposes for validating case study design except for "Internal Validity, which doesn't apply to exploratory studies Ibid., p. 36.

CHAPTER 2 - GENERAL BACKGROUND

2.1 GROWTH OF MEGA-PROJECTS

In an address to the American Society for Macro-Engineering the Chief of Engineers, Lieutenant General E.R. Heiberg III identified a mega-project's characteristics in the following way:

"...size; being beyond the capacity of a single organization; requiring the collaborative efforts of government and private firms; utilizing state-of-the-art technology; and, having economic, sociocultural, and environmental impacts that extend well beyond the project sponsors."/1

General Heiberg's description is appropriate although I will add, for the purposes of this paper, that modern mega-projects also generally exceed \$1 billion in current-dollar value. He touched on some of the characteristics that make mega-projects increasingly commonplace in the world economy. Although dominated in the 1970s and 1980s by modernization programs in the oil-rich states of the Middle East, future mega-project opportunities are more likely to result from the collaborative efforts of government, industry, and financial institutions from a heterogeneous mix of countries. The tunnel currently being constructed under the English Channel is a prime example of this new mix of partners.

Some would take exception to General Heiberg's assertion that mega-projects, by definition, use state of the art technology since the construction industry has always lagged behind manufacturing industries in technological advances. However, consider one of the fertile areas for 21st Century

mega-projects - construction in space. This will be impossible without significant developments in construction technology. Another growth area for mega-projects, environmental cleanup, will also require new construction technology to be successful. Thus, the interface between public and private sectors will be critical to ensure that there is adequate funding for research and development of new construction technologies.

Finally, we are becoming increasingly aware of the global impacts of international mega-projects. The world construction industry experienced a boom during the decade of intense construction in the Middle East, then suffered a recession when the programs were cut back in the mid-1980s. Mega-projects will likely be key to converting the lagging economies of eastern European countries under authoritarian rule into competitive free market economies. Also, as worldwide concern for a safe environment increases, the role of mega-projects in controlling environmental hazards (and in eliminating them) will become increasingly important. In a 1981 article on the Bechtel Group, Forbes summed up the importance of mega-projects to the future of the construction industry and identified the US world position in mega-project management:

"In a sense this vast engineering of whole systems is a growth industry as much as computers or communications are. It is what the world needs to develop scarce resources and to develop the undeveloped and lesser-developed. If the US is no longer the leader in manufacturing technology, it remains the leader in engineering technology on these grand scales." /2

In my opinion, the most significant development in the growth of mega-projects from a construction management perspective is that it signals the need for a different approach to construction management and a new breed of manager. General Heiberg recognized this when he said:

"The opportunities and challenges for [mega] projects are out there. To meet them will require new and broader thinking. We must be willing to work across national boundaries, across the traditional limits of professional disciplines, and in arenas that may be new and even strange to some of us..."^{/3}

It appears that global construction companies are also aware of the need for new thinking. Fortune magazine recently noted:

"From Amsterdam to Yokohama, recruiters are looking for a new breed of multilingual, multifaceted executive who can map out strategy for the whole world...To prepare for the wide-open world of 1992, companies are pushing out their traditional managerial corps of stodgy engineers and aristocrats."^{/4}

Although I don't focus on individual personalities in this thesis, I do examine the organizational cultures of the Corps of Engineers and Bechtel and determine whether they were adaptable to the mega-projects the companies managed. Ultimately, I attempt to identify organizational types and staffing philosophy which can consistently be applied successfully to a wide variety of international mega-projects.

2.2 KINGDOM OF SAUDI ARABIA DEVELOPMENT PLAN

Despite the vast reserves of oil discovered in Saudi Arabia during the 1930s and the West's increasing dependence on imported oil after World War II, the Kingdom's economy remained agrarian and at a subsistence level until the early 1970s. The first paved road connecting the old port capital of Jeddah with the new capital at Riyadh wasn't completed until 1967. The Kingdom's literacy rate was only 30% as recently as 1972 and the highest structure in Riyadh in 1968 was its water tower. Recognizing the need for Saudi Arabia to expand and modernize the structure of its economy, King Faisal created the Central Planning Organization (the forerunner of the present Ministry of Planning) in 1968. Ultimately, Saudi Arabia hoped to accomplish four long term objectives with its burgeoning oil wealth. It sought to maintain and improve the Kingdom's security and stability; increase its status as a leader in the developing world; diversify its economy from dependence on crude oil exports; and keep oil prices at a level that discourages oil importers from developing alternative energy sources. With help from Western economists the Central Planning Organization created Saudi Arabia's first five year economic plan, which covered the years 1970 to 1975./5

The theme of the first development plan was to build an infrastructure and create a national public education system by concentrating efforts in urban areas such as Jeddah, al-Khobar and Riyadh. The plan involved a rather modest outlay

of \$9.1 billion over the five year period. However, during the first five year plan Saudi Arabia's fortunes improved dramatically. Its phased buyout of US oil company interests in its national oil company, OPEC's newly discovered power, the 1973 Arab-Israeli War and the oil embargos which followed fueled a meteoric rise in the Kingdom's revenues. From 1973 to 1975 Saudi Arabia's national income grew 44% in real terms.^{/6} The Kingdom's ability to spend money on development lagged far behind its increasing revenues from sales of oil and natural gas. Saudi Arabia lacked adequate berthing facilities to unload freight. As a result, construction material intended for use in executing the first plan was often moored off its congested ports for six to eight months. In addition, the Kingdom's road transportation networks were inferior. This lack of infrastructure gave rise to the more ambitious second five year plan for the years 1975 to 1980.

The second plan focused on port, airport and highway construction to ease the movement of people and goods. In addition, it provided for huge outlays to correct the education, communications, health and housing gaps. The infrastructure problem so inhibited further development that the government created the General Ports Authority to improve the efficiency of existing ports and the Royal Commission for Yanbu and Jubail, a "...purpose-built agency devised by [Crown Prince] Fahad to avoid the red tape of existing bureaucracy."^{/7} It was under this second five year plan and Royal Commission supervision that Bechtel Corporation was

hired to build the port and industrial city at Jubail. The Kingdom allocated approximately \$80 billion to the second five year plan, an estimated \$30 billion of this to build the Jubail and Yanbu ports.

The third development plan, 1980 to 1985, came at the peak of Saudi national confidence and was extremely ambitious. The \$234 billion plan departed from its predecessors in several ways:

"While the first two plans concentrated on building an infrastructure, the Third Plan was to move on to industrialization, make agriculture self-sufficient, expand social services, limit the growth of bureaucracy, and distribute the wealth of the country more evenly among the people."/8

The theme surrounding the third development plan was "industrialization" and relieving dependence on foreign expertise and labor. A less publicized but equally important feature of the third plan was its \$100 billion allocation to the Ministry of Defense and Aviation to build infrastructure and procure weapons systems for each branch of the armed services. Most of the funding for the Corps of Engineers' construction of KKMC came from this plan.

Midway through the execution of the third development plan a worldwide recession, coupled with an oil glut, hit Saudi Arabia and almost stopped development in its tracks. Oil production and prices dropped nearly 75% during 1982 and 1983, causing the government to lower its development objectives. Riyadh cut military expenditures by 20%, despite increasing instability in neighboring states. It also cancelled some industrial construction programs outright and

delayed payments to many projects under construction. Virtually all elements of the third plan were cut back.

Since declining revenues continued into 1984, the fourth development plan (1985 to 1990) focused on themes rather than spending goals. The first theme was to diversify the economy through manufacturing, agriculture and finance. The second was to reduce the government's near total dominance of the economic system and to develop incentives for private enterprise. The third theme was to increase government efficiency and reduce bureaucracy. Finally, the plan called for reducing the Kingdom's dependence on foreign labor.¹⁹ Instead of heralding major new construction programs, it concentrated on maximizing output from the previous development plans. Saudi Arabia's performance on the fourth development plan is not complete but it's safe to say the Kingdom will make less progress on its goals than it did on the previous five year plans.

Considered from any point of view, Saudi Arabia's development during the past 20 years has been remarkable. In less than a generation, the Kingdom's economic base went from "manual agrarian subsistence" to "fledgling industrial" based on developing petroleum products and byproducts. Virtually every facet of Saudi society has been impacted. A country with no paved roads in the 1950s now has 25,000 kilometers of multi-lane paved highway; international class ports have increased from 3 to 15; airports with paved runways have grown to 54; the literacy rate has increased from less than

30% to more than 50% in 6 years and continues to climb; the country produces large amounts of cement, steel rods, electrical cable and desalinated water where none was made a decade ago; and the Saudis have become a net grain exporter./10 These impressive statistics are not intended to mask Saudi Arabia's severe shortcomings. Even after instituting massive programs providing technical training for Saudis, the Kingdom remains heavily dependent on expensive foreign skilled labor. The high cost of doing business in Saudi Arabia and the unyielding severity of its climate also hinder its attempts to enter competitive markets. Oil revenues remain flat and the government still subsidizes much of the Kingdom's output. The Ministry of Defense can only muster 5000 soldiers to man its 50,000-man showcase installation. Even considering these drawbacks Saudi Arabia's development plans, which provided the funding to plan and complete the Jubail and KKMC programs, achieved most of their goals and may have exceeded some of them.

2.3 US ARMY CORPS OF ENGINEERS

The United States Army Corps of Engineers is both a civil and a military engineering and construction agency. Its workforce of more than 40,000 civilians and 1000 military personnel makes it the single largest engineering and construction organization in the world.

"...the Corps is broadly responsible for military construction, military engineering supply and military engineering training programs. It is a major Army command and, as such, is the direct responsibility of the Secretary of the Army. As a civilian construction agency, the Corps is responsible for the design, construction, operation and maintenance of navigation and flood control improvements and related works."/11

2.3.1 HISTORY AND ORGANIZATION

The commander of the Corps of Engineers is a lieutenant general, called the "Chief of Engineers", who also holds an Army Staff position. His command consists of 13 Divisions (commanded by brigadier generals) and 40 Engineer Districts (usually commanded by colonels).

2.3.1.1 HISTORY

The Corps of Engineers has an important place in the nation's history. The Corps predates the establishment of the United States. The Continental Congress authorized its formation in 1775. It was disbanded in 1783, but reinstated in 1802 with the creation of the United States Military Academy at West Point, New York. West Point was the only technical engineering school in the country until Rensselaer Polytechnic was founded in 1825 and it was administered by

the Corps of Engineers until 1866./12

From its inception the Corps has been the predominant constructor of civil works in the nation. It was the engineering department of the government which planned and executed the internal improvements initiated in the 1820's, which included navigation improvements on the Mississippi and Ohio Rivers, construction of the Chesapeake and Ohio Canal and completion of the Cumberland Road. Rivers and harbors work has generally fallen under the Corps since 1852 and flood control since 1936./13 The Corps' civil mission currently includes many forms of conservation work, environmental protection and cleanup, and development work affecting water and wetlands./14 The Corps' water resources program currently has more than 1500 projects covering 25,000 miles of navigable waterways and 500 ports./15

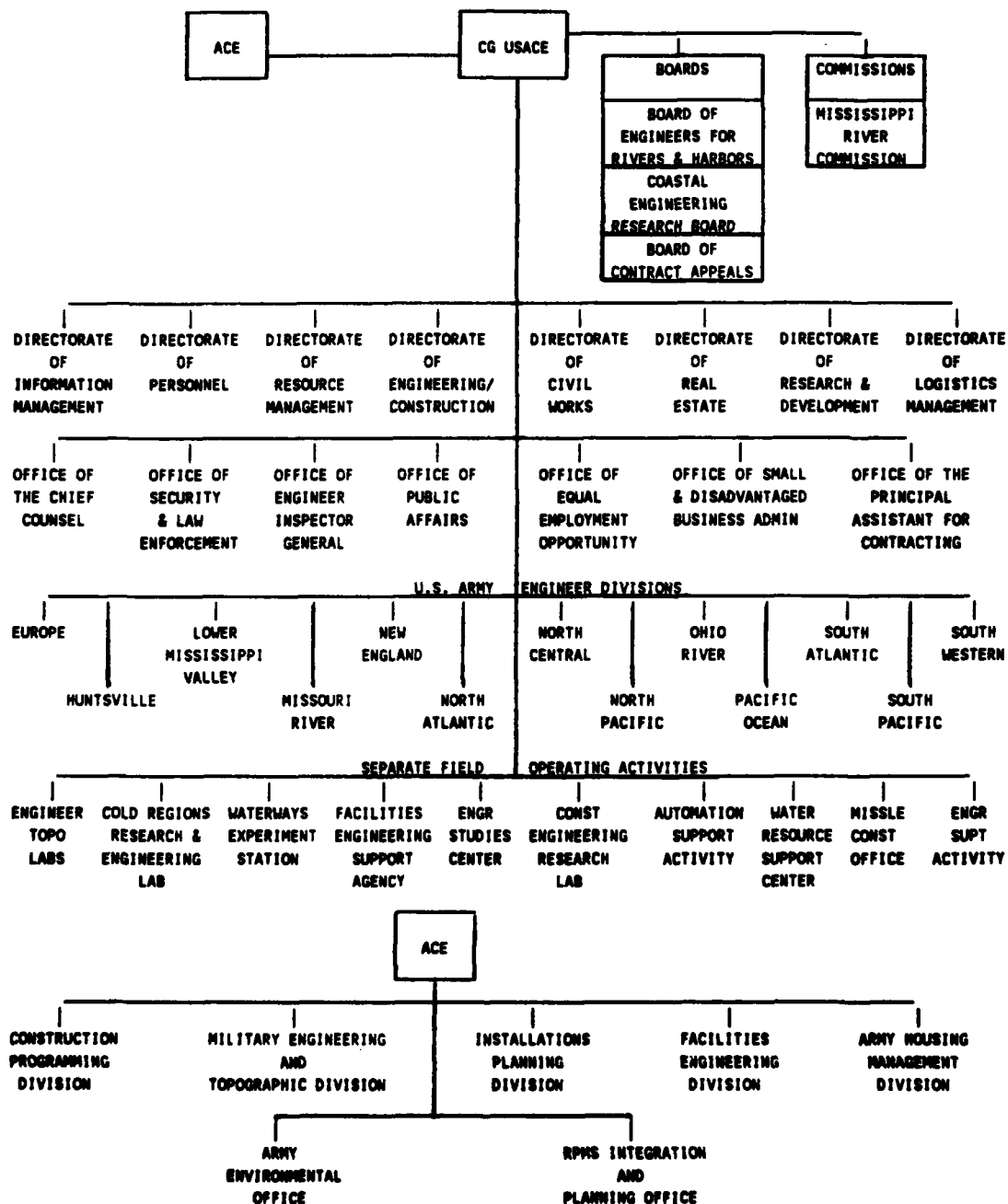
In its military role, the Corps of Engineers provides military facility construction support to the US Army and Air Force at home and abroad, as well as to friendly foreign governments when directed by Congress./16 The Corps is also responsible for Army facilities engineering, property maintenance and management of more than 24 million acres of real estate. In addition, the Chief of Engineers is responsible for the combat readiness of all military engineer soldiers, as well as for doctrinal development and emergency policies and plans. The Corps of Engineers also manages the Army's nuclear power program./17

2.3.1.2 ORGANIZATION

The US Army Corps of Engineers' current organization is at Figure 2.1. The Corps is a proponent of centralized planning and decentralized execution. Its organization reflects this philosophy. It generally places a great amount of construction management responsibility and contract administration authority at the lowest levels (at the resident engineer or area engineer offices within engineer districts) while maintaining responsibility and authority for engineering and program management at district and division levels.

The Corps of Engineers has an extensive network of laboratories and support activities to assist its construction mission. The Corps has four laboratories engaged in both military and civil construction research. The Cold Regions Research and Engineering Laboratory is located in Hanover, New Hampshire and has a field office at Ft Wainwright, Alaska. Its research concentrates on construction and engineering issues involving the nearly 70% of the earth which is subject to ice, snow, seasonally frozen ground, permafrost and sea ice.^{/18} The Waterways Experiment Station at Vicksburg, Mississippi performs most of the engineering research for navigable waterways and includes a scale model of the Mississippi River. The Construction Engineering Research Laboratory at Champaign, Illinois investigates engineering materials and methods in temperate environments. The Engineer Topographic Laboratories at Ft

FIGURE 2.1 ORGANIZATION OF USACE/19



Belvoir, Virginia researches military aspects of topographic engineering. In addition, the Corps has support activities involving toxic and hazardous materials, engineering and housing, automation, water resources and specialized management studies./20

2.3.2 EXPERIENCE IN SAUDI ARABIA

The Corps of Engineers first appeared in Saudi Arabia in 1951 as the construction manager for a US Air Force base at Dhahran. Years later, the base was turned over to the Saudis. During the lean years for Saudi Arabia that followed, the Corps continued to construct small projects funded by the US. The most significant of these was a \$5 million civil air terminal completed at Dhahran in 1961. In 1979, retired Lieutenant General Frederick Clarke (a colonel when he was responsible for construction of the terminal in the late 1950s) reminisced about the terminal,

"It won the first honor award of the American Institute of Architects as the most beautiful building designed by an American architect...I've always said it's because of that building that the Corps is still in Saudi Arabia."/21

The Corps' primary mission in Saudi Arabia was, "...to provide engineering and construction management services to Saudi military agencies, but it [was] also involved in other than military programs..." /22 After the early projects, Saudi Arabia entered into a series of formal country-to-country agreements with the US to manage projects funded by the Saudis. The programs involved both military construction

and civil works and the Saudis paid all Corps of Engineer expenses, including salaries. The nonmilitary projects consisted of a \$28 million television station completed in 1971 and a \$14 million radio station finished soon after. The Corps also participated in the Jeddah flood relief program in the mid-1970s.

The most significant of the country-to-country agreements executed by Saudi Arabia and the US was the Engineer Assistance Agreement (EAA), concluded on May 24, 1965 and extended five times. It called for the United States to provide advice and assistance in designing and constructing certain facilities for the Ministry of Defense and Aviation (MODA) and for training Saudi engineers./23 Under the EAA, the Corps built military cantonments at Khamis Mushayt (completed in 1971 for \$81.4 million) and Tabuk (completed in 1973 for \$81 million). In addition, USACE built several smaller military facilities across the Kingdom and completed a \$1.5 billion military academy in Riyadh./24

The crowning achievement under the EAA was the Corps' construction of the \$218 million port at Ras Al Mish'ab and the \$6 billion King Khalid Military City, the subject of one of the case studies in this thesis.

However, the EAA was only one of several agreements under which the Corps performed engineering and construction management services to the Saudis. USACE helped modernize the Saudi Ordnance Corps under a \$2.9 billion program created in 1966 by serving as contract administrator for the

maintenance and supply of ordnance and engineering equipment, as trainer for Ordnance Corps Cadets, and as disbursing agent for equipment purchases. The Corps constructed a \$300 million headquarters complex, other facilities and ranges under the 1972 National Guard Modernization Program. In addition, USACE acted as the design and construction manager on behalf of the US Navy for the \$5.2 billion Saudi Naval Expansion Program. This involved constructing naval bases with deep water ports at Jubail and Jeddah, a repair facility at Dammam and a naval headquarters complex in Riyadh. Finally, the Corps acted as contractor and construction manager under the US Air Force to modernize Saudi airfields at Dhahran, Khamis Mushayt and Taif during the 1979 Peace Hawk VII and Peace Sun II programs. In the Peace Hawk program, the Corps performed design review and quality assurance inspections during construction of support facilities for F-5 fighter aircraft purchased from the United States. USACE performed full construction management duties during the Peace Sun program to provide support facilities for the advanced F-15 fighter. The combined cost of these programs was \$545.6 million./25

The Mediterranean Division, located in Italy, was responsible for all USACE projects in Saudi Arabia from 1952 through 1976. As the amount of work in Saudi Arabia increased during the mid-1970s the Corps closed its Italian office (in 1976) and reorganized in Riyadh as the Middle East Division (MED), where it remained until 1986. At its peak

from 1980 until 1984, the Division consisted of districts at Al Batin and Riyadh, the Engineer Logistics Command (ELC) in Jeddah and a Division Rear Headquarters to monitor US design firms at Winchester, VA. The MED was also responsible for small projects in Oman, Egypt, Sudan, Kuwait and Bahrain. After completing its major programs in Saudi Arabia, USACE dissolved the MED and completed the remaining projects from a district-level element of the South Atlantic Division called the Middle East/Africa Projects Office (MEAPO), in Winchester. The total Saudi Arabian program, including KKMC, reached \$17 billion and was completed in 1988./26 USACE currently has no active projects in the Kingdom.

The Corps of Engineers' total Saudi Arabian Program was as extensive as any of the Kingdom's massive private programs. Saudi Arabia sought and received USACE assistance in part because it was impressed with the Dhahran civil air terminal and other early projects the Corps built with US funds. The Kingdom also lacked the expertise to manage a huge program at that time. However, equally important was the Corps' reputation as an effective and honest public servant. The Saudis preferred entrusting their defense construction to a government agency. Engineering News Record suggested that USACE was chosen over private firms because developing nations had, "...been burned by shoddy [private] design and construction supervision work."/27 Also, USACE was never perceived as a threat to perpetuate itself in the country. In any case, the Corps of Engineers' public service

role gave the Saudis confidence that they could delegate considerable authority to USACE and receive a good product at a fair price.

2.4 BECHTEL GROUP

Bechtel Group is a privately owned and operated corporation based in San Francisco, that "...has probably done more to transform the landscape of America and the world than any other company of this century."/28 After 92 years of family ownership, Bechtel Group has become one of the largest and most productive engineering and construction companies in the United States. It provides technical and management services to develop, manage, engineer, build and operate installations worldwide.

Bechtel developed from its humble beginnings in the Oklahoma territory into an international organization of 27,800 employees working for 950 clients on almost 1600 active projects and studies. Bechtel performed \$5.1 billion of work in 1989./29 Although not required and not willing to disclose its financial information to the public, Bechtel's \$13.6 billion in revenues for 1982, alone, would have placed it in Fortune 500's top 20, had it been listed on the public exchange./30 It has consistently been in the top 5 domestic construction firms in terms of dollar placement since Engineering News Record began publishing results in 1964. Unencumbered by the demands of shareholders, as Newsweek put it in a 1977 article, "Bechtel seems to have the best of both worlds: unlimited growth opportunities and the flexibility to pursue them pretty much as it pleases."/31

2.4.1 HISTORY AND ORGANIZATION

Bechtel Group's family-based origin and company leadership give a clue to its corporate personality and current organization. Bechtel is a hard driving, opportunistic, politically well-connected and secretive corporation, much like the family that runs it.

2.4.1.1 HISTORY

The Bechtel Group's history began in 1898 when its founder, Warren Bechtel, travelled from Kansas to Oklahoma territory with a team of mules looking for railroad work. By 1900, he was in Reno, Nevada working as an engineering estimator for Southern Pacific.^{/32} In 1906, Bechtel created his own construction company in northern California and hired himself out as a subcontractor on railroad work. Bechtel's company grew slowly over the next 25 years, concentrating primarily on railway and pipeline work. While still operating as a small subcontractor, Bechtel pioneered the use of trucks to haul construction supplies and to haul and dump soil.^{/33} Bechtel also developed the side-boom tractor for pipe laying.^{/34}

Warren Bechtel incorporated his company in 1925 and the new corporation made a national reputation for itself as one of an 8 member consortium which constructed the Hoover Dam under budget and ahead of schedule from 1931 until 1936. Since then, its name has become synonymous with big jobs, from multi-unit nuclear power plants to airports, refineries, defense and space facilities and rapid transit systems.^{/35}

The company became an international contractor after World War II and it maintains a sizeable presence overseas today. Since the mid-1970s, Bechtel has received significant revenues from overseas projects. In 1989, 48% of its new work was international./36 Bechtel has a reputation for technical and management innovation and was involved in developing project management concepts several years ago./37

Today, the Bechtel Group engineers and manages many of the world's largest and most complex construction projects. It is involved in construction of the Eurotunnel between France and England, a 170-mile portion of the Trans-National Turkish Highway, the Shoubrah El-Kheima fossil power plant in Egypt, an offshore gas development in Qatar's North Field, the SEMASS waste-to-energy project in Massachusetts, an international airport for greater Hong Kong, decontamination of Three Mile Island Unit 2 reactor, the Disney-MGM Studio Tour park in Florida and Boston's Central Artery and Tunnel project./38 This international construction management organization has performed more than 15,000 projects in 135 countries on all seven continents during its history./39

2.4.1.2 ORGANIZATION

Bechtel's somewhat secretive corporate personality has made the organization a mystery to outsiders for four family-run generations. Unlike most corporations, it doesn't publish an organization chart and places no importance in one. However, one can discern some of the critical elements

of the organization from publicly held information.

Bechtel's current organization is the result of adapting to industry trends from the last 30 years. The company expanded from its construction contracting role into design and engineering work after World War II. Although the corporation continued to perform most of its own direct construction through the 1950s, Bechtel became primarily an engineering and construction management company in the 1960s and, in an attempt to capture the largest share of total construction dollars, began offering additional services such as assistance in obtaining financing and providing advice on technological advances, taxation, labor relations and public affairs in the 1970s. As the construction industry becomes more competitive and risky, Bechtel subcontracts more and more of its direct construction work. It currently performs its own construction work on less than half of its projects./40

Bechtel has also become a more specialized company, focusing on large projects (\$25 million or greater) in electrical power generation, air and ground transportation, petroleum and chemical plants, environmental remediation, mining, paper plants, buildings, infrastructure and water storage and treatment facilities./41 During down business cycles, however, the company will pursue smaller projects within that realm.

To support its operations, Bechtel Group, Incorporated is organized into 8 companies, each responsible for a

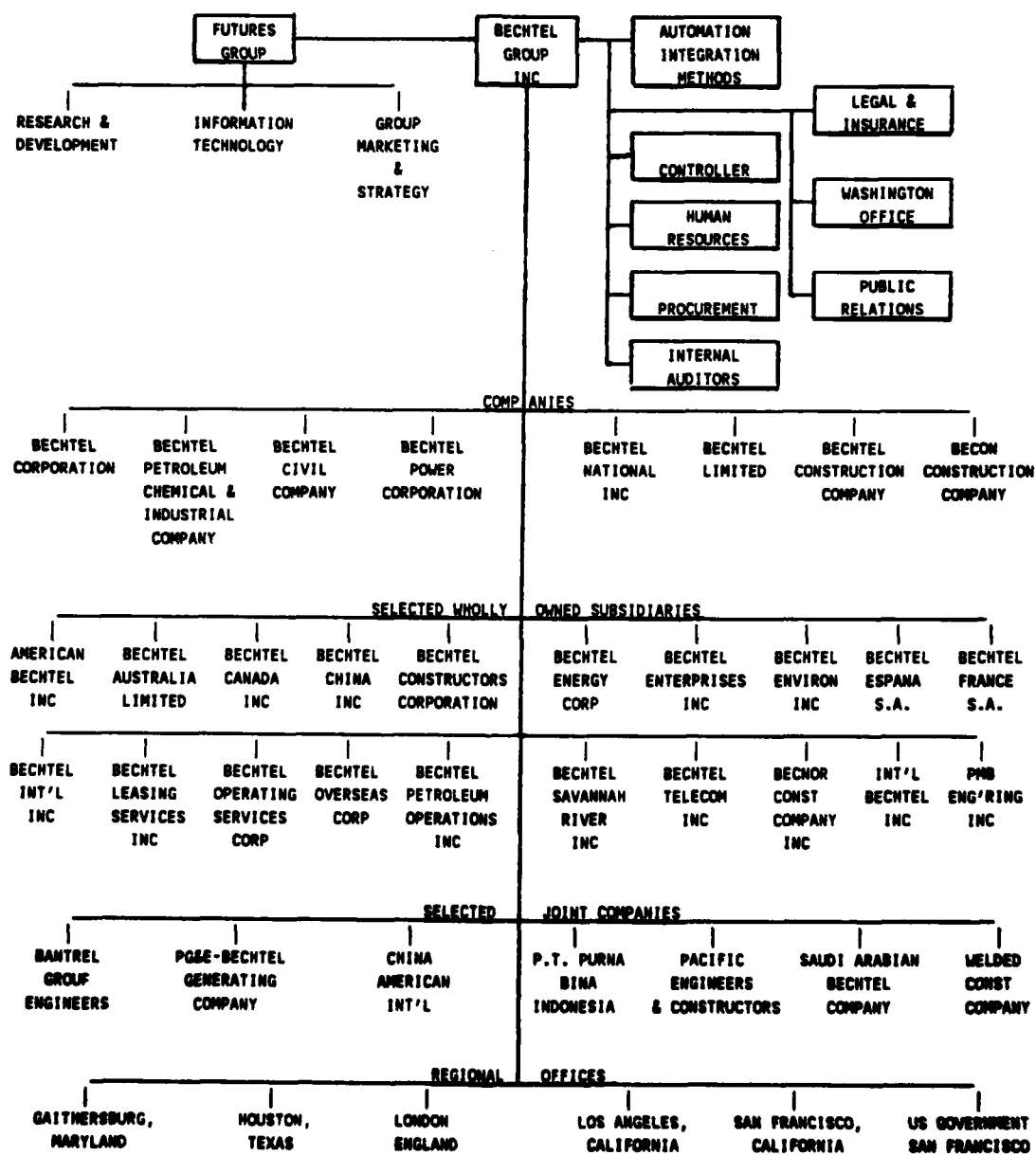
specialized business. Figure 2.2 breaks down the Bechtel Group into an organization table. There are 5 regional offices (one overseas) which include the engineering, construction and non-technical workforce needed to execute projects. There are also 22 major domestic and international offices and the US private engineering industry's largest research and development staff./42

2.4.2 EXPERIENCE IN SAUDI ARABIA

Bechtel first became involved in Saudi Arabia in 1943, when the company was called in at the request of ARAMCO to improve refinery facilities on the island of Bahrain and lay a 23 mile underwater pipeline from Bahrain to Ras Tanura in an emergency measure to increase supplies of oil to the Allies during World War II. In 1944, Saudi Crown Prince Faisal visited Bechtel's shipbuilding projects in California and was very impressed with the work. Sensing an opportunity in Saudi Arabia, Bechtel created a new division, International Bechtel, Inc., to focus exclusively on the Middle East./43

Soon, Bechtel was flooded with work from both ARAMCO and the Saudi government. It engineered and managed the 450,000 bbl/day "Tapline" for ARAMCO, a 1068-mile, 30-and 31-inch line across Saudi Arabia, through Syria to the Mediterranean Sea. At the same time, Bechtel became the principal public works contractor for the Kingdom. It built a railroad from Damman to Riyadh, the Jeddah and Damman harbors, the airports

FIGURE 2.2 ORGANIZATION OF BECHTEL GROUP/44



there and at Riyadh, provided the electrification of Riyadh and resurfaced the Mecca-Medina roads by 1951. However, Bechtel ceased working for the Saudi government in 1952, when progress payments fell behind by \$1.8 million./45

During the 1950s and 1960s, International Bechtel concentrated on projects in surrounding Arab lands, building pipelines, refineries, ports and hotels in Iraq, Syria, Kuwait, Lebanon, Abu Dhabi and Libya./46 Bechtel's emphasis returned to Saudi Arabia in the early 1970s, just in time to take advantage of the Saudi oil boom. It created a splinter company, called Arabian Bechtel Company, Limited (50% Saudi owned), and promptly won contracts to increase oil field production at Ain Dar, engineer and build the \$3.4 billion Riyadh International Airport, construct a natural gas liquid pipeline from Safaniyah and Uthmaniyah to Juaymah, build a 1600MW power plant at Ghazlan, and develop another oil field and lay a pipeline from Shaybah to Ras Tanura./47

Of course, Bechtel's 20 year contract to engineer and manage the construction of Jubail is, by far, the largest of the jobs resulting from the Saudi oil boom. However, Arabian Bechtel's Riyadh office had already managed billions of dollars of construction and had three decades of experience in the Kingdom before the Jubail project ever broke ground.

2.5 MANAGEMENT THEORY

Before performing case studies of the Saudi Arabian projects, it's appropriate to review current management theory regarding mega-projects. This review provides a summary of the state-of-the-art in project and construction management theory and provides an academic base of comparison for the management performance of the Corps of Engineers and Bechtel. Specifically, the review involves current theory on project organization and staffing, contract types and management of those contracts, resolving disputes and providing Owner Furnished Equipment (OFE) and materials to construction contractors.

2.5.1 ORGANIZATION AND AUTHORITY

Of the theories of construction management examined in this thesis, project organization and authority is the most thoroughly studied and developed. Still, most organizational research regarding construction is of industrial companies with internal construction divisions and permanent functional staffs. There is no body of research dedicated to organizing engineering and construction management firms such as the Corps of Engineers and Bechtel Group. Although there is no proven "best way" to organize and staff mega-projects, management researchers have developed some widely accepted theories.

Industrial companies generally organize according to functional or divisional forms. However, the core structure

of construction and engineering companies is the project. The organization of the project takes place within and is subsidiary to the overall organization form./48 This has spawned project management as an organizational form within the corporate structure. Project management has been described as, "...the mobilization and management of company resources for a finite duration for the purpose of completing a specific project."/49

Within the project organization of construction and engineering firms are the disciplines needed to serve the project, such as civil, structural, mechanical and electrical engineering. Recognizing the specialized nature of different types of construction projects, large construction and engineering companies often create divisions (or separate operating companies) to serve specific clients. For example, Bechtel Group has separate operating companies to handle airport, nuclear plant, petrochemical and space/defense construction projects. By combining expertise from these separate companies, large firms can undertake mega-projects which call for a combination of many specialized project types.

Growing from project management theory are three basic organizational alternatives for industrial companies performing construction projects: functional, matrix and pure project forms. Figure 2.3 shows the authority structure within these organizations. Table 2.1 identifies the factors influencing the choice of organizational and authority

structure for projects in industrial companies .

Engineering and construction companies almost exclusively use the matrix form to execute projects. At issue in the matrix organization is whether the project manager controls the functional elements (project driven) or the functional chiefs retain control with the project manager acting as coordinator (responsibility without authority). Albert Kelley sees the need for the project manager to have real authority over functions in mega-projects:

"With larger, more complex projects, the project manager and his staff, who have always been key figures, acquire much more responsibility: they must be innovative; they must be entrepreneurial; and they must be leaders."/50

In this thesis, I intend to identify the principles which should guide the overall mega-project management structure. The mega-project creates a complex set of interfaces. Stanford professor C.B. Tatum recognized the external influences which require project interfaces and combined them with goals and design and work technology to establish the project situation under which organizations are created.

First, Tatum stressed that mega-project organizations should reflect the goals of the owners and management firms involved in the project. Although technological challenges in design and construction practice are also driving forces in determining project organizations, he stressed that external influences should be considered when designing mega-project organizations. Major external organizations which influence construction/engineering firm organizations for

**FIGURE 2.3 CONTINUUM OF ORGANIZATIONAL AUTHORITY
STRUCTURES/51**

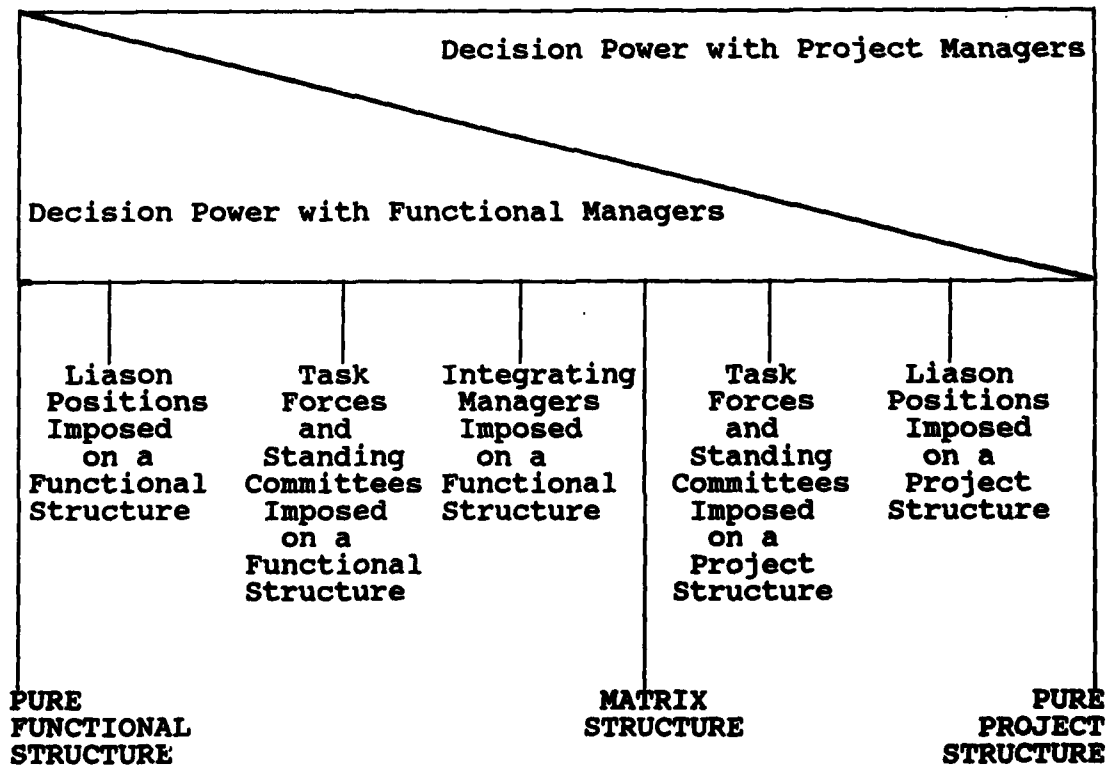


TABLE 2.1 FACTORS INFLUENCING CHOICE OF ORGANIZATIONAL TYPE/52

FACTOR	APPROPRIATE STRUCTURE	
	DECENTRALIZED	CENTRALIZED
1. Project size & duration	F	P
2. Organizational expertise (with other than functional organization)	Avoid M Try P	F, M, or P
3. Resources (funding & depth of in-house technical expertise)	M	P
4. Difference (uniqueness in comparison to the normal business of the firm)	F	P or M
5. Importance (urgency of the project)	F	P
6. Technology uncertainty (dynamic, unstable technology)	F	M or P with technical depth
7. Financial uncertainty (related to contract, technology & regulations)	F	M
8. Number of projects (work load from other projects)	P	M
9. Cost & schedule control (the need for tight control, anticipated difficulty in achieving it)	F	P
F = Functional; M = Matrix; P = Project.		

mega-projects include:

"(1) Owners; (2) operators; (3) the architect/engineer and the design contractors; (4) fabricators and suppliers; (5) construction contractors; (6) craft labor unions; (7) regulatory agencies; and (8) others unique to individual projects." /53

Having identified the situation under which mega-project organizations are established, Tatum listed seven criteria which should be used to evaluate potential organization types:

- "1. Establish clear responsibility for external interfaces with engineering, purchasing and operations.
2. Provide single point of responsibility at lowest practical level.
3. Integrate craft, engineering, planning, and materials resources at the lowest practical level.
4. Establish and enforce craft discipline priorities consistent with the construction phase of the project.
5. Limit manageable spans of control.
6. Assure clear and effective reporting relationships.
7. Assure most effective utilization of available management, support and craft resources." /54

I rate the two matrix forms used by construction and engineering firms to organize for projects against Tatum's criteria in Table 2.2. Tatum recommended that project managers create a decision matrix to evaluate alternatives for each project, emphasizing the criteria which are most important for the project. Additional criteria should be added for the unique characteristics of each mega-project.

2.5.2 CONTRACT TYPES AND MANAGEMENT

No particular contract form is universally recognized as superior to others. There is, however, general agreement on the proper approach for mega-project contracting and

**TABLE 2.2 TABLE OF ORGANIZATIONAL EVALUATION FOR
CONSTRUCTION/ENGINEERING FIRMS PERFORMING
MEGA-PROJECTS**

ORGANIZATION TYPES CRITERIA	MATRIX W/ FUNCTIONAL CONTROL	MATRIX W/ PM CONTROL
(1) Responsibility for External Interfaces	Strength	Strength
(2) Single Point Responsibility at Lowest Level	Weakness	Strength
(3) Integrate Resources at Lowest Level	Neutral	Strength
(4) Discipline Priority Consistent with Phase	Neutral	Strength
(5) Limit Span of Control	Weakness	Strength
(6) Clear and Effective Reporting Relationship	Weakness	Strength
(7) Effective Use of Management, Support & Craft Resources	Strength	Weakness

management. Contract packages are one of the most important tools for engineering, procurement, construction management and overall project management of mega-projects./55 The key issues regarding contract type and management include, "...making equitable allocations of risks, liabilities, responsibilities and authority and incorporating them clearly in contractual arrangements."/56 At an Engineering Foundation Research Conference on mega-projects, the participants identified the following considerations in selecting contractual arrangements:

1. **Purpose of the Project** - Public service or profit.
2. **Funding Availability and Cash Flow Schedule** - All available; uncertainty of amount available and when; even if committed may come in an uncertain trickle.
3. **Desired Completion Date** - Also interim dates; schedules tight or ample.
4. **Time Available for Design(s)** - For complete project or parts barely ahead of construction contract.
5. **Availability and Qualifications of Owner's Staff** - For design and for construction management.
6. **Availability and Qualifications of Engineering and Construction Resources.**
7. **Affects** - Number and type of design packages and schedule for each; possible engineering consultants; optimum size and number of construction contracts and related design packages; construction management assignment - early.
8. **Location of Project** - Remote; urban area; near or far from manpower and material sources.
9. **Geological and Climatological Conditions.**
10. **Laws or Regulations** - Public agencies.
11. **Policies and Experiences** - Private agencies.
12. **Availability of Real Estate** - Timing
13. **Facilities or Services Owner Should Furnish.**
14. **Allocation of Risks and Liabilities** - Between owner, designer and contractor./57

After considering the varied and often interrelated aspects of mega-projects listed above, five basic types of construction contracts are recommended:

1. **Firm Fixed Price or Lump Sum** - Generally required

for public works and other government construction. Establishes the firm funding requirement for accomplishing a particular piece of work. Usually based on having sufficient time to have a fully engineered design and specific set of contract documents. Also requires the construction contractor to shoulder most of the risk for cost escalation.

2. **Cost Reimbursable** - Has several variations, including cost plus a fixed fee, cost plus an award fee and cost plus a percentage of cost. It transfers risk for cost escalation to the owner. It also provides greater flexibility to the owner for changing work under the contract. It is based on expectations that the contract will require changes because of design developments or changed local, international or physical conditions.
3. **Target Plus Incentive** - Combines some of the features of both fixed price and reimbursable contracts. Owner and contractor share risks of cost escalation, while the contractor has additional monetary incentives for keeping costs down.
4. **Fast-Track** - Used when time is considered paramount and it is desirable to start construction before the design is completely engineered. Owner bears risk for cost escalation. Used when higher construction costs are justified by faster delivery of a (usually revenue-producing) facility.
5. **Turnkey** - Similar to fast-track, except that a single contract is let for needed design and construction. Concentrates responsibility on one agency but tends to reduce competition because there are few firms capable of concept-design-construct operations. Owner generally bears risk of cost escalation up to a negotiated amount. 58

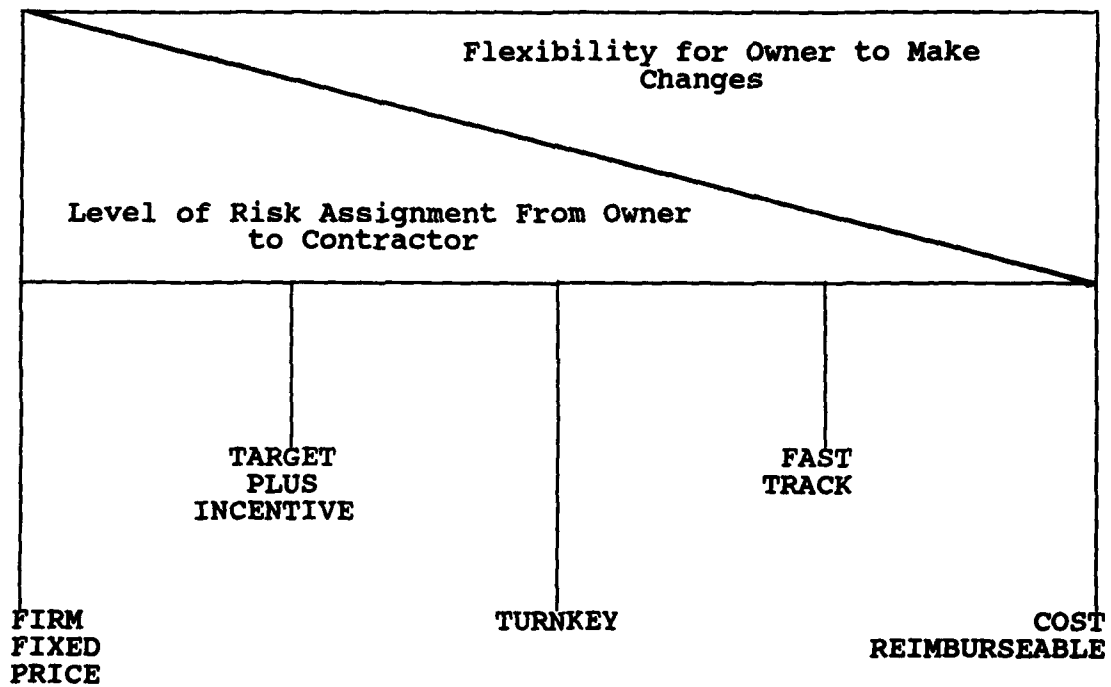
In particular, who accepts the risks for the 14 factors described earlier is the primary source of contention in mega-project contracts. Most construction firms agree that owners should accept more risk than is normal when contracting for mega-projects because the dollar amounts of risks are so great, there is great difficulty and expense in insuring the risks, there are more unknowns and more factors

beyond the contractor's control.^{/59} Traditionally, owners have tried to assign as much risk as they can to their contractors. Considering the magnitude of the mega-projects, however, owners are reexamining the cost-benefit of this approach and, more frequently, are adopting other than fixed price contracts. Figure 2.4 compares owner flexibility with risk assignment in a continuum across the different types of contracts.

Although fixed price contracting is still acknowledged as an effective way to promote competition and reduce owner risk of price escalation if used under the proper circumstances, some facets of most fixed price contracts are being criticized. For example, the Better Contracting for Underground Construction Report pointed out that, "...fairer allocations of risks between the parties and better procedures for avoiding or settling disputes and minimizing [work] disruptions..." in fixed price contracting would lead to more satisfactory project completion.^{/60} In addition, many project managers question fixed price contracts' suitability for mega-projects, which generally involve fast-tracking design and construction concepts and greater risks of cost escalation due to environmental restrictions, remoteness and international finance.

In recent years a hybrid of fixed price and cost reimbursable contracting has gained favor on mega-projects. An example of this comes from the Alaska Pipeline Project, where contracts were advertised based on fixed prices for

FIGURE 2.4 CONTINUUM OF RISK ASSIGNMENT IN CONTRACT TYPES



costs of contractor-furnished equipment, salaried personnel and off-site overhead, a fixed fee and reimbursable labor./61 The key point in considering this type of contracting is that owners are beginning to recognize the usefulness of altering traditional contracts to address the unique requirements of mega-projects. Creative managers can equitably share the risk of cost escalation with contractors by varying a standard contract. In the James Bay electric generation project, for example, the owners contractually indemnified their contractors for 80% of unknown labor cost escalations. The contractors were responsible for 20%, giving them sufficient incentive to control labor costs./62

Researchers maintain that the success of contractual arrangements depends not only on choosing the best contract form, but also matching it with the appropriate management philosophy for the specific project and its situation. Rules, responsibilities and authority of the key parties should be spelled out clearly in the contract./63 Managers should also strive to eliminate confusing and duplicative layers of authority and decision making by spelling out authority and responsibilities in the contract.

Sol Kutner, an executive consultant at Bechtel Group, summarized the prevailing industry view of factors that should be considered when formulating a complete contracting strategy for superprojects:

1. Carefully divide the project into specific work packages of a definitive scope.
2. Establish work packages early.
3. Select the best contract formula to meet the needs

- of each work package (lump sum, target plus fee, etc.).
4. Survey the contractor and supplier market to determine guidelines for optimum contractor/supplier response.
 5. Stay flexible in order to maintain contractor confidence in a changing market, a market which varies with cost escalation and work load.
 6. Define services to be furnished by owner. Do not overextend owner's service capacity.
 7. Plan for large equipment fleet needs.
 8. Consider having owner furnish bulk materials, such as rebar and concrete, at fixed cost to all contractors.
 9. Include bonus and penalty clauses in contracts. /64

2.5.3 DISPUTE RESOLUTION

There are two current schools of thought regarding how to resolve disputes on mega-projects. One contends that the best way to resolve disputes is to avoid them, by creating contracts which are unambiguous and correctly assign responsibilities and by using management techniques which emphasize teamwork and problem solving. The other school acknowledges that some disputes are unavoidable and it's best to try alternative methods of dispute resolution which end short of litigation. Considering the great risks inherent for owners and contractors in mega-projects, a successful management strategy for resolving disputes may combine both schools of thought.

When disputes are unavoidable, current theory is that alternate dispute resolution (ADR) techniques often prove to be the most cost-effective and least divisive way of resolving them. The primary dispute resolution techniques are arbitration (binding and non-binding), mediation, mini-

trial and litigation. Their attributes are summarized in Table 2.3.

Managers must make an informed decision of whether to choose a form of ADR over litigation. Some factors to consider are:

1. It may not affect the ultimate amount of a settlement when compared to litigation but ADR generally reduces the cost of arriving at a settlement.
2. ADR is usually very effective in addressing highly technical or industry-specific issues.
3. Some forms of ADR allow great control of one's own destiny, avoiding the uncertain outcome of litigation (and binding arbitration).
4. Voluntary ADR is a "no risk" situation; any party may back out at any time and seek settlement through traditional methods.
5. ADR Preserves business relationships.
6. ADR allows parties to meet face to face rather than through intermediaries.
7. Even when unsuccessful, ADR can enhance the effectiveness of litigation by allowing both sides to prepare their cases and air much of the dispute before meeting in court.
8. ADR can be disadvantageous when it is not to the advantage of one of the parties to resolve the dispute promptly.
9. ADR proceedings can be made private.
10. ADR prohibits joining third parties to the proceedings./65

ADR methods of are not available under the laws of some countries involved in international contracting and there are even more alternatives available in others, so construction managers should thoroughly research options for dispute resolution before writing construction contracts on

TABLE 2.3 ATTRIBUTES OF DISPUTE RESOLUTION METHODS/66

ATTRIBUTE	COURT	ARBITRATION	MEDIATION	MINI-TRIAL
Appearance of Parties	Involuntary	Voluntary or Contractual	Voluntary	Voluntary
Relation of Parties	Adversarial	Adversarial	Cooperative	Cooperative
Who Presides?	Assigned Judge	Arbitrator Selected by Participants	Neutral Selected by Participants	Neutral Selected by Participants
Technical Knowledge of Neutral	No Specialty	Can Select Based on Knowledge	Can Select Based on Knowledge	Can Select Based on Knowledge
Structure of Proceeding	Highly Structured; Inflexible	Rules May be Set by Parties, Though Usually Structured	Very Flexible	Rules May be Set by Parties Though Usually Somewhat Formal
Decision Rendered?	Decided by Third Party	Decided by Third Party	Settled by Mutual Agreement	Settled by Mutual Agreement
Decision Binding?	Binding	Binding and Non-binding	Non-binding	Non-binding
Appeal Allowed?	Appealable	Not Usually Appealable	N/A	N/A
Forced Revealing?	Discovery	Limited Discovery	No Discovery	Limited Discovery
Rules of Evidence Applies?	Rules of Evidence	No Rules of Evidence	No Rules of Evidence	Rules of Evidence Mutually Agreed
Disclosure	Public	Confidential	Confidential	Confidential

international mega-projects. After more than ten years of experience with ADR, most construction managers are convinced that, when applied under the right circumstances, ADR can resolve disputes more economically and more quickly than court action while maintaining better business relationships.

2.5.4 OWNER FURNISHED EQUIPMENT (OFE)

OFE procurement is a common contract management technique used on mega-projects to save costs and time. OFE can speed delivery of long lead items, such as major pieces of mechanical equipment. Often, it also accomplishes the objective of obtaining shop drawings required to do the engineering for lump sum construction contracts. However, OFE's usefulness has often been questioned. Many managers feel that the additional costs of managing OFE procurement, delivery, storage and maintenance, as well as the increased risk to the owner of claims resulting from late delivery, overshadow its cost benefits.

Researchers at the University of Illinois, Urbana, recently performed a study of 55 projects involving OFE and made some interesting conclusions of costs and benefits. They are summarized below:

OFE Benefits

1. There was an average cost saving of 6.4% of the furnished product and 0.7% of total project costs. This was a consistent finding and did not vary with project size.
2. Typical time savings to deliver OFE were 3.7 months.
3. There were fewer product disputes than under

traditional procurement (7% versus 10-15%) and reduced dispute costs and delays.

OFE Costs

1. There was an estimated additional project cost of 0.2-0.4% for contract administration.
2. Owner should dedicate one person (organization) to monitor OFE contracts throughout the project for best results.
3. OFE is not appropriate for every project or product./67

The researchers also found that 75% of OFE supply contracts mentioned the anticipated time that the equipment was required on the job site for informational purposes. The specified delivery date for the OFE was almost always the same in both the supply and construction contracts, leaving no float in the documents./68 Finally, the researchers determined that retaining a substantial amount (5% or more) against the OFE supply contracts led to considerable improvements in delivery times, while cost savings were negligible./69

The remoteness of sites and speed of construction required in many mega-projects adds to the opportunities to provide OFE. On smaller, domestic projects, mechanical equipment accounts for 86% of OFE supply contracts./70 However, the owner often provides services as well as equipment to contractors on mega-projects. These services can include worker housing and food, utilities, access roads and bulk construction materials, such as cement, reinforcing steel, aggregate and fill. In addition, OFE can facilitate the engineering of preassembled components. Thus, not only

can OFE speed up the design and delivery process but it can also improve construction assembly time.

Industry representatives are quick to point out that OFE is not a panacea on every mega-project. Bechtel Quebec's Peter Behr summed up industry reservations by warning:

"Each project must be examined according to its own needs in this regard. Care should be taken to avoid infringing on contractors' responsibilities. An overambitious owner may end up with some major headaches if he is not prepared to live up to all commitments."/71

2.6 OTHER CONSIDERATIONS

This thesis involves in-depth case studies of mega-project planning, organization, staffing and control. It examines many of the management issues which are crucial to the successful completion of large international projects. However, several issues that the thesis doesn't address in detail can be equally critical. They include environmental concerns, interpersonal skills for project managers, and project finance. I will discuss them briefly here.

Environmental impact assessment of mega-projects is now commonplace all over the world. More important, managers are beginning to realize that environmental engineering is as critical to the planning and design effort as traditional engineering functions are. Environmental considerations will impact the planning and execution of future mega-projects. In addition, correcting or avoiding environmental hazards will become a major source of future mega-projects. The Boston Harbor Cleanup Project is a prime example of the growing need for environmental mega-projects. For these reasons, mega-project engineering/construction managers must be more environmentally aware and capable than their predecessors.

Modern mega-projects also require their managers to have more proficiency in interpersonal skills than before. The global nature of construction contracting routinely brings together representatives of many different countries and cultures to plan, design and build mega-projects. Often,

marshalling far-flung resources and developing effective lines of communication are more challenging than the engineering aspects of these projects. Engineering/construction managers must have the capacity to communicate effectively with owners, engineers and contractors. In addition, they often act as mediators of the conflicting interests represented by these parties.

For example, mediating skills are critical for the \$12 billion Channel Tunnel's program manager. Disputes and cultural differences between English and French members of the construction consortium caused it to hire an American with international mega-project management experience as its chief executive. He won praise, "...from both Eurotunnel and his own employees by vastly improving coordination between the separate British and French construction crews." /72

It's evident from this example that mega-project managers need highly developed interpersonal skills to compliment traditional planning, organizational, and engineering skills.

Another facet of modern mega-projects is the requirement for innovative financing to get them started and keep them going. Financing wasn't a factor in either of the Saudi Arabian case studies. However, it's likely that future mega-projects, even in Saudi Arabia, will require significant financing. Therefore, the managers of these projects must become familiar of the increasingly complex array of financing available to support them. Many project decisions have a financing component. The mega-project manager must be

aware of its implications and adjust planning to accommodate it.

One should not infer from the omission in this thesis of environmental, interpersonal skill and financing issues that they're not important. On the contrary, these issues can often make or break a mega-project. I don't examine them in detail because it's not clear from my research that they were major issues in the Saudi Arabian case studies. Still, they're worthy subjects of future study.

2.7 CASE STUDY FOCUS

In the preceding sections I've emphasized the importance of studying mega-project management, established the research methodology, summarized the Saudi Arabian experience of the case study subjects and discussed pertinent management theory. At this point, it's appropriate to identify the focus of the case studies that follow.

A major difference in mega-project management from that of smaller projects is the requirement to spend huge sums of money effectively, efficiently, rapidly and steadily. By its nature, this requirement exceeds the capabilities of most engineering/construction management firms in the world. Only a small number can marshal the necessary resources and expertise and organize to accomplish the mission. Therefore, the focus of the USACE and Bechtel case studies is to determine how those organizations get the job done. I'll research four key management tasks on the KKMC and Jubail mega-projects; (1) planning, (2) organization, (3) staffing and (4) control and identify the critical components of these tasks for in-depth study. I'll identify USACE's and Bechtel's successes and failures in their respective case studies. Then I'll compare and contrast their approaches to mega-project management. Finally, I'll determine strategies for planning, organizing, staffing and controlling international mega-projects which should have universal applications. My goal is to generate hypotheses of management principles that can be applied successfully to any

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CHAPTER 3 - CASE #1: US ARMY CORPS OF ENGINEERS AT KING KHALID MILITARY CITY

3.1 CASE BACKGROUND

At more than \$6 billion, King Khalid Military City is the largest military construction project ever undertaken by the US Army Corps of Engineers. Design work began in 1976, soon after USACE was directed by the State Department to perform as the project's design and construction manager. USACE completed facilities for one armored brigade at KKMC in 1984. King Fahd inaugurated the city on April 6, 1985 and USACE completed construction of KKMC in 1987. Saudi Arabia's Ministry of Defense and Aviation (MODA) now controls and operates KKMC with engineers from its General Directorate of Military Works (GDMW) who were trained by USACE./1

This chapter is a case study of the construction management techniques applied to this international mega-project by USACE's Middle East Division (MED) and a determination of their effectiveness. The first portion of the chapter provides background on the KKMC project and its challenges. The remainder of the chapter examines how USACE addressed those challenges and determines the effectiveness of its management efforts.

3.1.1 ENGINEER ASSISTANCE AGREEMENT

The Engineer Assistance Agreement (EAA) was a country-to-country pact concluded on May 24, 1965 between the US Ambassador to Saudi Arabia and the Saudi Minister of Foreign

Affairs. It was sponsored by the US State Department. The EAA called for the United States to provide advice and assistance in the design and construction of certain military facilities for MODA, funded by Saudi Arabia, as well as providing a training program for Saudi engineers./2 The two countries agreed that the US Army Corps of Engineers would be the agency to perform the assistance defined under the agreement. Ultimately, the agreement was extended five times and USACE performed most of its Saudi Arabian program, including construction of KKMC, under the EAA's guidelines.

The EAA warrants more than just passing attention because some of its provisions were far-reaching and farsighted. They had a great impact on USACE's management philosophy for KKMC and, later, became sticking points in relations between MODA's GDMW and USACE.

Some of the important statements regarding construction management made in the EAA include:

1. The Corps shall be entirely responsible for the administration of all construction contracts awarded under the terms of this agreement.
2. ... the contractor shall receive instructions only by the contracting officer.
3. The Corps shall have the right to issue change orders to construction contracts as required by field conditions, technical and engineering considerations, construction problems encountered,...
4. Change orders that would change the authorized scope of the facilities being constructed will be issued only with the concurrence of the Saudi government./3

In essence, the EAA made USACE an agent of the Saudi Arabian government, acting for and on its behalf. This arrangement

gave USACE full control of design and construction management efforts with GDMW acting as Program Manager.

During the early years of the Saudi Arabian program, this arrangement worked very well. GDMW had a large budget but virtually no qualified engineers and managers and no construction industry base to work from. The Saudis welcomed the Corps of Engineers' expertise and delegated the necessary authority to compliment it. However, by 1983 the Saudis had developed a core group of USACE-trained engineers, the country had a growing construction materials industry and GDMW was running short of funds. This combination of developments caused GDMW to increase pressure for an active role in construction management.

According to Tom Olson, Al Batin's District Counsel, the Saudis began restricting EAA authority in the early 1980s. GDMW began requiring USACE to submit constructability change orders and claim settlements for approval.^{/4} At times, GDMW review was slow, even on changes which were intended to improve constructability. USACE perceived this GDMW involvement as a compromise of the EAA. In some cases, it reduced construction management efficiency and increased costs. However, USACE chose not to raise its concerns beyond its MODA liaison. The Corps attempted to foster teamwork and avoid more serious dilution of its construction management authority by generally complying with GDMW's wishes.^{/5}

By 1985, as government funding purse strings for KCMC continued to tighten, GDMW focused on review and approval of

claim settlements. Although the status of the owner (GDMW) in USACE's construction management system was never resolved to the full satisfaction of either party, USACE was able to hang on to the strengths of the EAA and complete the program with it intact.

An examination of owner - construction manager relationships is beyond the scope of this thesis. However, I briefly summarized the EAA because the agreement defined USACE involvement at KKMC and had a significant effect on how it organized and conducted its business. It is worth noting that clearly defining the role of the construction manager and the owner in advance is a prerequisite of effective mega-project management.

3.1.2 FOREIGN MILITARY SALES ACT

Although the EAA guided USACE's organization for and management of the KKMC program, the Foreign Military Sales Act (FMSA) determined that the US would become involved in the program. The FSMA became Public Law 90-629 on October 22, 1968 and was modified six times from 1971 through 1976. Section 2769 set policy for foreign military construction sales.

Its primary provisions are that the President may sell design and construction services to any eligible foreign country if that country agrees (1) to pay the full amount of a contract which assures the United States Government against any loss on the contract and (2) to make funds available in

such amounts and at such times as required to meet the payments under the contract and any damages and costs of cancellation of the contract in advance of when they are due. The President delegated his functions under this law to the Secretary of Defense in a 1977 Executive Order. Unlike the EAA, the FMSA did not spell out the extent and explicit terms of Defense Department involvement in providing design and construction services to foreign governments./6

Due to Saudi Arabia's strategic importance in the 1970s and its oil wealth, the Kingdom easily met the FMSA's prerequisites. This paved the way for Corps of Engineers involvement in the KKMC project under the terms of the EAA.

3.1.3 STATIONING DECISION AT AL BATIN

USACE's first task during its involvement in the KKMC project was to perform studies of suitable areas for construction of a divisional-sized military city in Saudi Arabia. In 1974, the Saudis had cantonments at Khamis Mushayat (in the west near the border with troubled Yemen) and Tabuk (in the northwest near the border with Jordan and traditional enemy Israel). Other than its naval and air installations on the east coast and armed forces headquarters in Riyadh, the Saudis lacked a defense presence near its border with Kuwait and the radical countries of Iraq and Iran. Establishing a sizeable installation in that area became a priority during the Kingdom's second five year development plan.

The Corps of Engineers commissioned several studies of the barren region near the Iraq/Kuwait border and eventually recommended a site 35 kilometers south of the Iraqi border, in a desolate area near the 5000-person village of Hafar AL Batin. The site is 450 kilometers north of Riyadh and 550 kilometers from the closest port, at Dammam. In addition, the closest improved road to Al Batin was the aged Tapline Road, built by Bechtel in the late 1940s. It came no closer than 95 kilometers to Al Batin (at Quaisumah) and required extensive upgrading to become a primary access road. Al Batin is 15 kilometers from a road between Riyadh and Kuwait that was eventually completed by the Saudis in 1978. There was no existing labor force or basic utilities in the Al Batin area.

Actually, none of the sites contemplated by USACE boasted an infrastructure, so the driving selection criteria were the base's proximity to the Iraq/Kuwait border and favorable soil conditions for construction. Al Batin provided this combination and GDMW selected it for development in 1975. Figure 3.1 on the following page shows KKMC's ultimate location.

3.1.4 POLITICAL CONSIDERATIONS

There were many political considerations which affected USACE's construction management approach for KKMC. They ranged from congressional reluctance to employ the American government's civil works experts in a foreign country, to

FIGURE 3.1 MAP OF SAUDI ARABIA SHOWING LOCATION OF KKMC/7



protests over Saudi boycotts of Jewish workers and products, to US construction firms' international lack of price competitiveness in fixed-price contracting.

The first issue, at the beginning of the KKMC program, revolved around a congressional debate of whether to employ the Corps of Engineers in such a massive foreign program. USACE had just completed a four year struggle with the Carter administration to maintain its role as the nation's primary civil works manager when the House Appropriations Committee criticized USACE in an annual report for stretching its manpower pool by taking on the massive Saudi projects, alleging that its domestic capabilities suffered as a result. The Chief of Engineers defended USACE involvement in the program, saying that the Saudi work helped to hone and maintain the agency's construction management skills. He stressed that the Saudi mega-project would produce and train the future engineers and managers of American military and civil works mega-projects./8

By this time, Saudi Arabia had become strategically important to the US. The Saudis were staunchly anticommunist and, many felt, would provide a bulwark against Russian intrusions into the Middle East. In addition, they had become the leading supplier of foreign oil to the United States. As some US officials saw it, the Corps of Engineers could be used to cement ties between the two nations - at no cost to the US taxpayer./9

The argument expanded and took on additional foreign

policy implications as a result of USACE involvement in engineering and constructing two fast tracked military airports for the Israelis during the same period. Not only did this put a further drain on rapidly shrinking Corps of Engineers manpower resources but it created a potential diplomatic war over loyalties to adversaries separated only by the Gulf of Aqaba. Remarkably, USACE was able to deflect most of the criticism of this arrangement by having two completely separate divisions control the projects (North Atlantic Division managed the Israeli airfields), each in relative secrecy./10

The controversy regarding USACE managing construction for feuding countries died down in the late 1970s. Then congressional investigations regarding the Arab League's blacklist and boycott of several companies with Jewish or Israeli ties sprung up to replace it. In 1976, the United States Justice Department filed an antitrust suit against Bechtel Corporation for cooperating with the boycott. The case was eventually settled out of court and a Senate filibuster defeated anti-boycott legislation. However, during its hearing, Bechtel's defense lawyers accused USACE of participating in the boycott for ten years through a provision in the EAA./11 Even though the EAA did give the Saudis, "...the right to reject any contractor on the [prequalification] list submitted by the Corps," none was rejected during USACE's entire Saudi Arabian program./12

Still, USACE generally complied with Saudi government

requirements for its individual workforce, at least regarding employees located in Saudi Arabia. USACE avoided (though it did not prohibit) stationing Jewish employees in Saudi Arabia, although they were free to work on the program from the Division Rear office in Virginia. When USACE ignored the boycott, it did so surreptitiously to avoid incensing the Saudis. In the long run, the Arab League boycott had virtually no effect on the quality of services provided by USACE although it caused a small black eye to the Corps' public image in the United States.

The final and most pressing political consideration for USACE during construction of KKMC involved its attempts to provide work for US architect/engineers, suppliers and construction contractors. Although USACE had a mandate from Saudi Arabia to ensure the project was open to competitive international bidding, the Corps also felt an obligation to secure work there for American companies. The difficulty in meeting both requirements was that, by the mid-1970s, US contractors were less competitive on the international market due to high labor costs. To compound the difficulty, US personal income tax reform legislation in 1976 removed the tax exemption American overseas workers had enjoyed for years. As a result, US firms working in Saudi Arabia had to increase compensation packages by an average of \$4000 to \$10,000 per employee to offset income lost to the new tax./13

Interestingly, the tax reform had no direct effect on USACE's competitiveness because military personnel and civil

service employees had never been authorized a tax exemption for working overseas. It did, however, impact the Corps' attempts to provide work for American contractors.

In comments made just prior to his retirement as the Chief of Engineers, Lieutenant General John W. Morris said about the Corps, "Our job [abroad] is to make a place for US designers and constructors."/14 Early in the EAA program, US firms did capture a significant number of contracts. By the middle of 1976, USACE had awarded 43% of its \$1.5 billion in contracts to US companies. Still, critics of government involvement charged (rightfully) that even when US firms won construction contracts, most of the labor wages went to foreign workmen. "If the aim is to bring petro-dollars back to the US, then the whole deal is overrated," one House member said./15

After tax reform, US firms fared poorly. American companies won only 5 of 39 construction contracts at KKMC (all awarded after 1976) for approximately \$1.5 billion, only 25% of the city's construction cost. All but \$400 million of this total went to the Morrison-Knudsen led consortium which received the life/construction support contract on a negotiated basis./16 There turned out to be some truth in a congressional critic's prediction that USACE would evolve into an "employment agency" for foreign contractors./17

American architect/engineers and suppliers fared much better than construction contractors, though. Virtually all design work went to US firms and many of the sophisticated

mechanical, electrical, communications systems and finish products came from American manufacturers. MED's decision to maintain its design and procurement headquarters in the United States enhanced the competitive advantage of American companies in these areas. All factors considered, USACE probably did as well as could be expected in providing opportunities to US firms during construction of KKMC.

3.2 PROJECT SIZE AND SCOPE

Lieutenant General E.R. Heiberg concisely summarized the scope of the KKMC undertaking in his speech to the American Society for Macro-Engineering when he said:

"The challenge was to take the remote desert of Wadi Al Batin with no infrastructure, forty miles from the nearest highway, extreme congestion at the nearest port over 100 miles distant, no local labor force, no available construction materials (except aggregate) with wide price fluctuations and annual price escalations at 20-25%...to take this environment and create the King Khalid Military City for a population of [50,000]."/18

KKMC is a self-contained city, completely independent of the surrounding area. It is octagonally shaped and 2.7 kilometers across. It generates its own electrical power, has its own water supply and chilled water system and completely treats and recycles its wastewater for irrigation. KKMC has its own road network, houses and provides all support facilities for the city's 6500 families and has its own hospital, mosque and education system. The current city has complete military support and training facilities for two armored brigades, with the capability to expand to accomodate a third. The troop facilities include a command center, engineer school, maintenance shops, ammunition and petroleum storage areas, ranges and a medium-sized airfield.

The octagonally-shaped city is divided into north and south sections. Family housing dominates the north section, while housing for single men and military facilities dominate the south. KKMC was assembled from precast concrete elements. Most of the city's buildings are arranged in low-rise clusters to provide natural protection from the harsh

environment./19 The design, by Brown, Daltas and Associates/Sippican Consultants International (JV), combined features of traditional Islamic architecture with modern technology to produce a functional community which is less opulent than much of the contemporary work done throughout the Kingdom.

Some statistics give the engineer a better feel for the magnitude of the city:

- 2.5 million square meters of buildings (27 million square feet).
- 18 wells, each 1600 meters (approximately 1 mile) deep to provide 21 million gallon of water per day, with a peak demand of 30 mgpd.
- A water treatment plant designed to treat 18 mgpd.
- A chilled water plant rated at 52,000 tons.
- A sewage treatment plant designed to treat 7 mgpd.
- A 200 mega-watt power plant with 8 gas-turbine generators.
- The entire city, including training ranges, was built on a mere 70,000 acres of land./20

The effort required to bring the forces to bear in creating this city was, of itself, a major undertaking. The dedication of KKMC on February 1, 1978 also represented the initiation of serious construction on life support and construction support facilities. The first task for MKSAC (USACE's support contractor) was to construct a camp to feed and house up to 15,000 workers. It also constructed warehouses, vehicle and equipment shops and administrative offices for construction contractors. Simultaneously, MKSAC

began stockpiling material and equipment to be provided contractors by the government.

Tasks that MKSAC had already completed by Dedication Day included lengthening an existing airfield for contractors, paving 6 kilometers of road to the site and constructing several VIP villas.

MKSAC completed camps for 1200, 1500 and 5000 workers, as well as villas and trailers for USACE and MKSAC senior employees by mid-1979. It also provided temporary utilities to the worker community until permanent KKMC utilities (some also provided by the support contractor) became available.

Early construction support activities concentrated on supplying adequate concrete and aggregate for construction needs and on developing warehouse space for material and equipment provided as GFP. MKSAC eventually built two concrete batch plants and an asphalt concrete plant, developed a quarry 20 kilometers from the site, erected 12 materials warehouses and provided computer and data processing centers. The largest operation provided by MKSAC was for precast concrete. The support contractor built and operated four precast plants, three for producing building elements and one for paving tiles.^{/21} These statistics highlight the construction effort.

- Construction of a 4 berth port about 250 miles from the construction site and dedicated to support the massive construction effort.
- Used more than 500,000 precast elements and 10 million walkway pavers.
- Engineering and design costs exceeding \$135 million,

yet less than 2% of total project costs of more than \$6 billion.

- A \$1 billion contract for life and construction support including the world's largest pre-cast concrete plant (at that time), an asphalt plant, quarry, bulk concrete production and housing, food and medical services for all construction workers.
- 12 separate construction contracts exceeding \$100 million, with the largest single contract at \$330 million.
- A work force exceeding 15,000 people at its peak.
- A program requiring 12 years to complete (1975 - 1987); major construction was completed in 6 years (1979-1985)./22

The figures on the following pages consist of a KKMC area map (Figure 3.2), a KKMC site plan concentrating on life support and construction support areas (Figure 3.3) and a more detailed site plan breaking the city into areas which were packaged into separate construction contracts (Figure 3.4).

FIGURE 3.2 KKNC AREA MAP/23

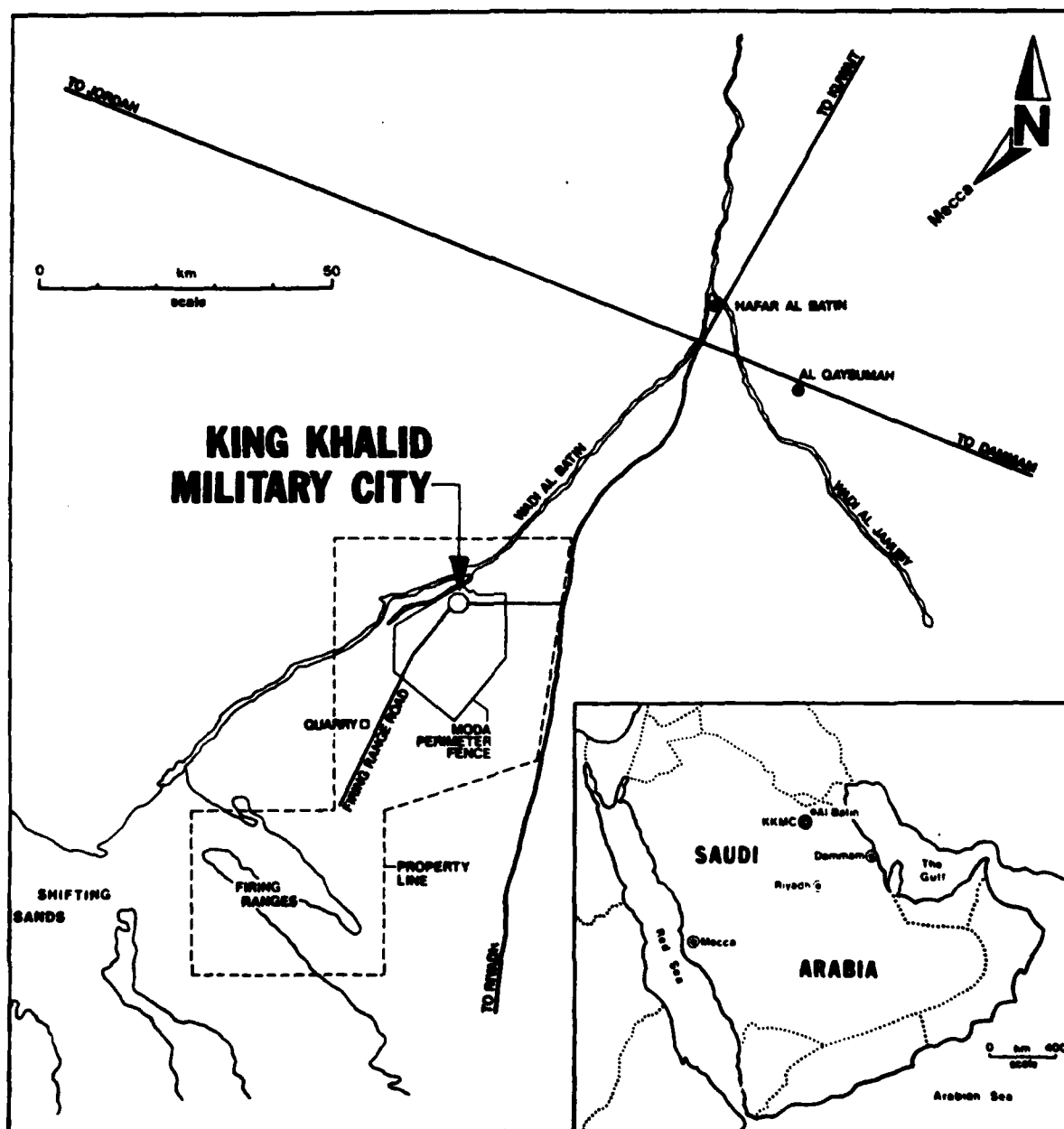


FIGURE 3.3 KKM LIFE AND CONSTRUCTION SUPPORT SITE PLAN/24

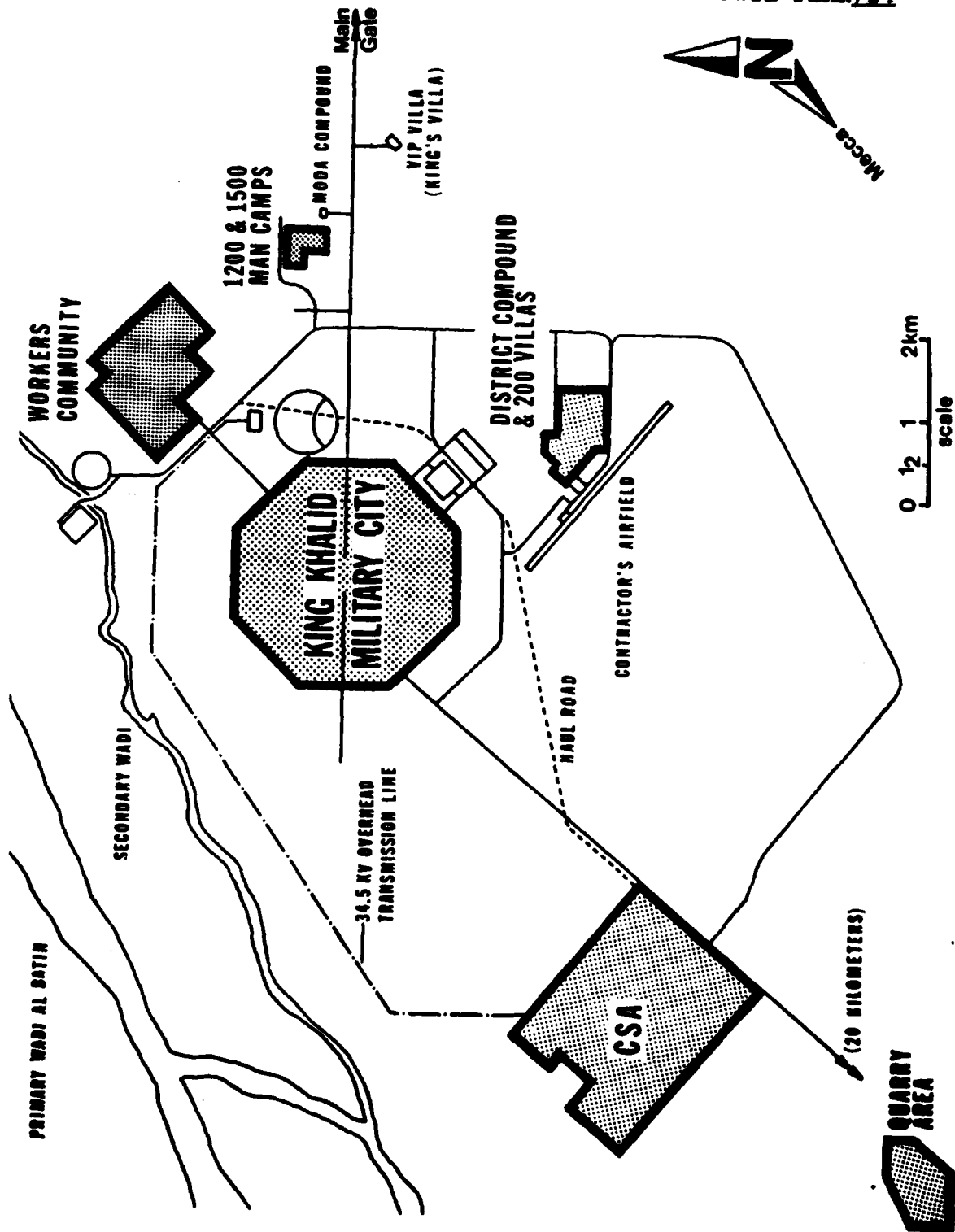
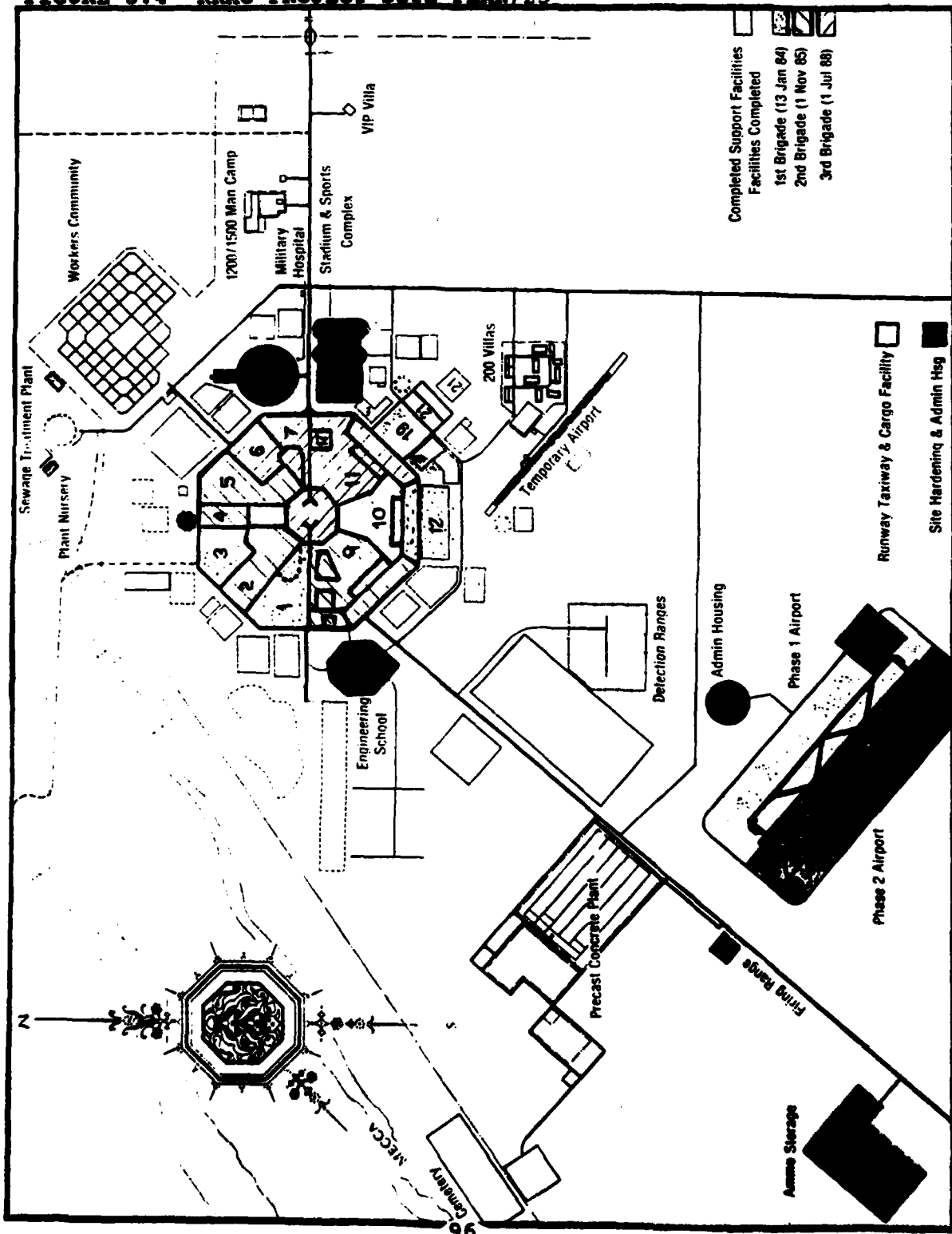


FIGURE 3.4 KMC PROJECT SITE PLAN/25



3.3 PROJECT PLANNING

USACE had performed many mega-projects in its history but most were civil works. KKMC loomed as the largest single military construction project in its history. It was the first time that USACE had attempted to build an entire military city from scratch. Clearly, the effort required an unprecedented planning effort. This section examines USACE's planning of the KKMC project and determines its effectiveness.

3.3.1 PLANNING OBJECTIVES

The Engineer Studies Center at USACE headquarters prepared "A Plan for Project Planning" for MED in April 1978. Its purpose was to provide the Saudi Program Manager with a way to approach planning of individual projects. Since USACE produced the guidance document two years after MED began detailed planning for KKMC, it had limited impact on the project. However, it provides a basis for evaluating MED's planning efforts on KKMC.

"A Plan for Project Planning" identified the following objectives of a formal project planning strategy:

1. Streamline project administrative and support activities to facilitate technical execution of the project.
2. Minimize unproductive time in the project definition stage.
3. Provide a "contingency" capability during the project execution stage./26

MED concentrated on planning activities during three distinct

project planning phases: (1) Project Preplanning or Programming Phase; (2) Master Planning Phase; and (3) Project Execution Phase. By 1978, MED was in the third of its project planning stages for KKMC. The remainder of this section focuses on whether MED met its objectives during these planning phases.

3.3.2 KEY PLANNING ISSUES

MED faced several key issues during each of the project's planning phases. I'll identify what the critical issues were and evaluate the Division's plan to address them in this portion of the study.

3.3.2.1 ISSUES DURING THE PROGRAM PLANNING PHASE

The primary issues MED faced during the earliest planning phase were general and of a macro nature but they carried consequences that affected every detailed project activity that followed. The issues were:

1. Who would perform the project planning in MED?
2. Who would produce the conceptual design?
3. What were owner requirements for the project?

The MED Commander followed established USACE guidelines and directed that project planning be done centrally at the Division Rear in Virginia. The Chief, Engineering Division was responsible for project planning and he formed a team from the rear office. He retained project planning authority during the construction program and his office provided

continuity throughout the planning phases. The Office of the Chief of Engineers (OCE) also had a big part in making some of the early key decisions but it eventually pulled out of project planning. The eventual Project Manager for KKMC hadn't been selected and no representatives of the MED staff who were already located in Saudi Arabia took part in the planning. The Engineering Division did an exceptional job getting the macro planning initiated.

One of the successes of the KKMC project was the excellent work of its design contractors. MED recognized the need to hire a skilled A/E firm immediately to perform location and requirements studies. It hired Brown, Daltas and Associates to perform the necessary program studies and the firm performed excellent work.

The final issue faced by the project planners in this phase was to ascertain owner requirements for the project. This turned out to be one of the weakest aspects of the entire effort. The blame lies partially with MED for not seeking detailed owner involvement and with MODA (the owner) for being unsure of what it wanted. It appears that MED never cultivated a close owner - manager planning relationship. The planners were oriented to making decisions that would give the design process momentum. MODA was an impediment to the process. It was easy for the planners to develop this attitude because of their great geographical separation from MODA's project managers in Saudi Arabia. There were few Saudi representatives in Virginia. As a

result, the planners lacked an understanding of the project's cultural considerations and under-designed the city for its Saudi culture./27 For example, the oversight caused a sizeable delay in awarding the family housing contracts. MODA rejected the initial design after it had been completed because it felt the individual units were too small for Saudi families./28 The costly delay for redesign could have been avoided if there had been a more detailed owner - manager - designer review in the conceptual stage.

3.3.2.2 ISSUES DURING THE MASTER PLANNING PHASE

During the master planning phase, project planners made critical decisions about what to design and how to organize and build it. Although they didn't begin detailed designs at this point, the planners made a number of decisions with organizational, constructability and project control implications. Here are some of the more important ones:

- MED would procure and furnish a large amount of equipment, material and services to construction contractors.
- The Division would construct a port facility designed to support only military construction projects in Saudi Arabia.
- A/E firms would be required to produce state-of-the-art designs for military facilities.
- Construction would be performed to US standards.
- Construction design and contract award planning would be based on a 5 year construction schedule.
- MED would produce a precast concrete city and achieve economies of scale in all utility design.
- Construction contracts would be firm fixed price and

limited to 3 years at \$100 - \$200 million apiece to improve international competition.

By and large, the project planners developed a workable master plan. However, it exhibited significant construction inefficiencies and other drawbacks when put into motion. For example, the plan to use American material standards and measurements caused construction contractors difficulty later. They had trouble cross-referencing American standards to materials from European and Asian suppliers. MED could have avoided the submittal review delays and materials rejections that resulted from its policy if it had developed a cross-reference guide for its construction managers.

Another case involved the precast concrete elements designed for the city. MED hoped to reduce costs while maintaining high construction quality by assembling the city from precast elements produced by the construction support contractor. However, MED lost much of the potential economy of scale that precast offered because it failed to standardize panel designs. The design called for more than 5000 different types of elements with over 3000 variations (for penetrations, utilities, etc.) out of the half-million pieces required for KKMC. Construction managers claimed that the city could have been built with 300 to 400 different elements if the design had been properly coordinated./29

The final example of constructability problems stemming from the master plan involved coordinating utility tie-ins between adjacent contractors. The Al Batin District Engineer used the water supply system as an example of the

coordination problems encountered during the peak construction period:

"...most of the water system can be run through either of two different pipes to get to a specific location, and sometimes more than two...we had some 17 fixed price contractors that had put in portions of the water system, and those get connected together at some 57 locations...it's a difficult enough task to make sure that you have caps on the end of the pipes and valves at the proper locations so that if one contractor can finish his work before the next contractor [he can] hook on to those pipes and carry on with his work."/30

It's clear from this example that the planners put more effort into system design than contract interfacing, which is a constructability issue.

The preceding illustrations highlight a serious flaw in the master planning which carried over into the project execution phase. Al Batin District's Chief, Construction Division summed it up. "I think there was nothing wrong with the design being done back in the rear. What the real problem was -- there wasn't cohesive construction planning along with it."/31 Construction planning wasn't performed because no representatives from the construction functions were on the planning staff to provide a builder's perspective. The Engineer Studies Center recognized the need for construction planning in this phase and recommended placing members from field offices on project planning teams beginning in the master planning phase. However, this didn't happen during the KKMC project and construction managers paid the price.

3.3.2.3 ISSUES DURING THE PROJECT EXECUTION PHASE

The consequences of the issues I discussed in the previous two sections carried over into the project execution phase to cause difficulties for the construction managers. In addition, a new planning oversight during the third phase impaired contract award and sequencing. The oversight was a lack of contingency planning. The study performed by OCE for the Middle East Division indicated that contingency planning is a key ingredient of the project execution phase. It recommended that the Division develop construction plans to address three levels of project execution: accelerated, optimal and protracted. By doing this, MED would have made plans for the most likely MODA funding alternatives. Initially, though, MED made only one plan for project execution. It was based on the MODA budget for a 6-year construction schedule, from the end of 1976 through the end of 1982.³² Project planners agreed that this was the fastest they could expect to complete KKMC. However, by 1978 it was obvious that the project wouldn't be completed that quickly. The primary reason for the slowdown was that MODA reduced the level of project funding. MED was unprepared for the cuts.

The Al Batin District Engineer then directed his staff to prepare construction plans for 8 and 10 year programs. He produced these plans at Al Batin in concert with his MODA liaisons. The District Engineer's major concern was to ensure that he sequenced contract awards and construction correctly. These factors varied considerably with different

construction program lengths./33 Ultimately, MED completed the KKMC project using the 10-year plan but it didn't realize all of the plan's potential cost savings because it was initiated late.

3.3.3 CONTRACTOR RISK REDUCTION

The objective for much of MED's KKMC planning was to reduce the risks that its firm fixed price construction contractors would face when bidding the project. The planners felt they could lower project costs by reducing contractor risk. Contractors facing less risk would theoretically place lower contingency costs in their proposals, thus reducing the price of the lowest bidder. The planners maintained they could simultaneously increase competition by lowering risk. Smaller, but otherwise qualified contractors who couldn't secure bonding against high contingencies would be able to bid if the risks were lowered. For these reasons, MED aimed much of its project planning at reducing risk for firm fixed price contractors. I'll discuss whether MED accomplished this objective in the following sections.

3.3.3.1 GOVERNMENT FURNISHED EQUIPMENT AND MATERIALS

The cornerstone of MED's risk reduction program was its Government Furnished Equipment, Materials and Services program (hereafter called GFE). The plan included MED's negotiated life/construction support contract with Morrison

Knudsen Saudi Arabia Consortium (MKSAC), a dedicated port at Ras Al Mish'ab and an extensive GFE procurement program. MKSAC, which provided the Services portion of the plan deserves separate treatment. I'll discuss it in the next section. This section concentrates on port services and GFE.

From its earliest project planning, Middle East Division worried about delays in unloading equipment and materials at existing Saudi ports. Dammam, the closest port to Al Batin, had dozens of cargo ships mired offshore collecting huge demurrage charges in 1976. Since the Kingdom was just launching an ambitious 5-year development program, there was no relief in site. Fixed price contractors became increasingly reluctant to bid on projects or placed huge contingencies in their bids to offset the risks of losing schedule control from port delays. Therefore, MED planned and built a 4-berth port north of Dammam at Ras Al Mish'ab. It would handle only material and equipment for MODA projects, primarily for KKMC. MED finished the first phase of the project and had a functional port by July 1977. For the next several years, the Engineer Logistics Command (ELC) operated the port and tracked GFE that arrived there. Even though the project had a dedicated port, it was still 250 miles from the construction site and connected by a tenuous supply route. However, MED performed some road improvements and continuously monitored its condition during the project. The port worked effectively and international contractors

displayed confidence in it. This was reflected in many bids below Government Estimates on early contracts.

MED was less successful in planning its GFE program. When the Engineer Studies Center performed a lessons learned survey on the Saudi Arabian Program, its GFE planning and execution received the lowest rating of any aspect of MED work./34 Most of MED's problems with GFE can be traced to poor planning. Some of the major ones follow:

- No central control of GFE.
- Coordination lacking among engineering, construction and procurement.
- ELC got responsibility for GFE too late.
- ELC staff was too small with too few expert logisticians.
- Tracking system never effectively worked./35

Project planners failed to define a GFE Program Manager and segmented its functions among several offices./36 They established no direct chain of responsibility and authority. As a result, Procurement and Supply Division in the Virginia Office, Huntsville Division and MKSAC (through its support contract) ordered GFE. MKSAC and ELC tracked and received the material and equipment in Saudi Arabia. There was no common tracking system or directed coordination between the organizations. Material often arrived too early or too late, some of it didn't meet specifications and packing lists were inaccurate./37

Although MED's problems with GFE didn't have a major impact on contractor bids, they caused claims, disputes and

delays after contract award. MODA lost confidence in MED's ability to manage the GFE program. It pressured the Division to change its procedures and, in 1980, MED assigned responsibility for the entire GFE program to ELC. By then, it was too late to recover the benefits envisioned during program planning. MED reduced GFE's scope and required contractors to procure more of their own materials and equipment.

3.3.3.2 LIFE/CONSTRUCTION SUPPORT

The cost plus award fee (CPAF) negotiated contract with MKSAC deserves special treatment because it was the centerpiece of MED's Government Furnished Equipment, Materials and Services Program. Planning for the entire project hinged upon MODA's acceptance of a CPAF contractor to provide life and construction support services to the firm fixed price builders. I'll discuss MED's management of the CPAF contract in Section 3.5 of the thesis. Here, I'll concentrate on the planning behind the life/construction support concept and evaluate its effectiveness.

Without question, MED made a risky decision when it planned to negotiate a \$1 billion contract with a consortium for life/construction support of the entire KKMC project. The consortium's performance would be pivotal to the project's completion in its planned 6 year period. Therefore, the planners emphasized that the consortium be headed by a large, respected international construction firm

with a solid track record in mega-projects. It eventually settled on Morrison Knudsen and its partners Fischbach and Moore (Dallas) and Interbeton Construction N.V. of Curacao (a precast concrete specialist). The contract with MKSAC had the following scope of work:

Design & Construction of Construction Support Facilities

- Rough grading, underground utility lines, perimeter and construction roads in designated areas of the project.
- Design, procure and erect precast concrete plants.
- Construct concrete and asphalt batch plants.
- Construct and operate aggregate quarries.
- Transport GFE from the port to KKMC.

Contractor Support Services

- Operate electrical generation plants and distribution systems, sewerage, air conditioning and refrigeration systems.
- Provide rental vehicles and construction equipment to support contractor mobilization.
- Receive and store all GFE.

Life Support

- Provide, maintain and administer contractor housing for 20,000 workers.
- Construct contractor support buildings, such as warehouses, storage areas, offices, maintenance and POL facilities.
- Provide medical and dental services.
- Operate and maintain food service for contractors.
- Provide postal, messenger, recreation, laundry, reproduction, security, communications and banking.

Management Assistance

- Participate in design review.
- Coordinate life/construction support services.
- Project construction equipment needs for all

construction.

- Provide personnel to augment the MED construction management staff./38

MED's planning for the life/construction support contract was detailed and effective. The Division built its construction plan around MKSAC. MED integrated the support contract into all aspects of design and construction planning. The planning for MKSAC's life/construction support contract was good. The concept should have worked, but it didn't. MED's experience with the CPAF contract was a disaster. Although it completed the original 3-year contract, MKSAC lost its bid to extend for another three years. MED essentially fired MKSAC in 1980. The problem with the MKSAC contract was not in planning but in contract administration and control. I'll examine the control weaknesses in detail in Section 3.5.

3.4 PROJECT ORGANIZATION AND STAFFING

USACE's project organization and staffing metamorphosed during the 12 year duration of the KKMC project. Though carefully planned initially, the actual organization and staffing differed significantly from the plan. This was a result of unforeseen recruiting and construction difficulties, as well as changing requirements from the owner. In this section, I examine USACE's organization and staffing throughout the project and determine the effectiveness of its selections.

3.4.1 ORGANIZATION TYPES

Within the USACE organization, Division Offices are the equivalent of divisions or separate operating companies in private engineering and construction firms (see Figure 2.1 for USACE Divisions). The rapid growth of the entire Saudi Arabian program, of which KKMC was a part, caused USACE to create a new Division Office in 1976. The US Army Engineer Division, Middle East (MED) was responsible to the Chief of Engineers to perform all construction projects in the Middle East, except for those in Israel. Most of the projects were in Saudi Arabia, but there was also work in Jordan, Oman and Egypt.

The analysis of organizations in this section will concentrate on MED's organization and those of the Engineer Logistics Command and District Office at Al Batin.

3.4.1.1 ORGANIZATION DURING PLANNING (1976 - 1977)

During the planning stage, MED established an organizational precedent which remained in effect until the Division was dissolved in 1986. Its most important objectives were to develop an organization which could simultaneously: (1) Manage design by American engineering companies; (2) Manage massive construction by foreign firms; (3) Manage procurement and supply of Government Furnished Equipment (GFE); and (4) Accomplish the first three objectives at the lowest possible cost. During the planning stage, MED consolidated its organization in the United States. Initially, the Chief of Engineer's office was heavily involved. It provided the impetus to negotiate a CPAF life/construction support contract and supplied the lead negotiator from its Military Programs Directorate. There was almost no permanent party in Saudi Arabia dedicated to KKMC until 1977. The only in-country contingents were an Area Office located in Riyadh under the Saudi Arabian District and a few people at Al Batin supervising well and airfield construction. Figure 3.5 shows a simplified MED organization as it planned for construction of KKMC after award of the CPAF contract.

During this period the organization was a matrix form with strong functional control. The Saudi Arabian District established the KKMC Area Office. The Area Engineer served as Project Manager. The Area Office was located in Riyadh, but it maintained a Project Office at the Division Rear's in

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graph TD
    MED_EXEC[MED EXECUTIVE OFFICE] --> Advisory[Advisory and Administrative]
    MED_EXEC --> Technical[Technical]
    MED_EXEC --> Staff[Staff]
    MED_EXEC --> Field[Field Offices]

    Advisory --> PERSONNEL[PERSONNEL]
    Advisory --> ADP[ADP]
    Advisory --> SAFETY[SAFETY]
    Advisory --> OAS[OAS]
    Advisory --> COUNSEL[COUNSEL]
    Advisory --> COMPTROLLER[COMPTROLLER]

    ADP -.-> HUNTSVILLE["(1) HUNTSVILLE DIVISION  
(Procurement Assistance)"]

    Staff --> DIVISION_REAR["DIVISION REAR *"]
    DIVISION_REAR --> PROCUREMENT_SUPPLY["* PROCUREMENT & SUPPLY"]
    DIVISION_REAR --> COUNSEL["COUNSEL *"]
    DIVISION_REAR --> OAS["* OAS"]
    DIVISION_REAR --> PUBLIC_AFFAIRS["PUBLIC AFFAIRS *"]

    Technical --> CONSTRUCTION_DIVISION[CONSTRUCTION DIVISION]
    CONSTRUCTION_DIVISION --> TECHNICAL_BRANCH[TECHNICAL BRANCH]
    CONSTRUCTION_DIVISION --> CONSTRUCTION_MANAGEMENT_BRANCH[CONSTRUCTION MANAGEMENT BRANCH]
    CONSTRUCTION_DIVISION --> CONSTRUCTION_PROGRAMS_BRANCH["CONSTRUCTION PROGRAMS BRANCH *"]
    Technical --> PROCUREMENT_SUPPLY[PROCUREMENT & SUPPLY]

    Staff --> ENGINEERING_DIVISION["ENGINEERING DIVISION *"]
    ENGINEERING_DIVISION --> PLANNING_BRANCH["PLANNING BRANCH *"]
    ENGINEERING_DIVISION --> TECHNICAL_BRANCH["TECHNICAL BRANCH *"]
    ENGINEERING_DIVISION --> PROGRAMS_REPORTS["PROGRAMS & REPORTS *"]
    ENGINEERING_DIVISION --> PROJECT_MANAGEMENT_BRANCH["PROJECT MANAGEMENT BRANCH *"]
    ENGINEERING_DIVISION --> FOUNDATIONS_MATERIALS["FOUNDATIONS & MATERIALS *"]

    Field --> ENGINEER_LOGISTICS[ENGINEER LOGISTICS COMMAND]
    ENGINEER_LOGISTICS --> FIELD_OFFICE["FIELD OFFICE  
RAS AL NISH'AR"]
    Field --> SAUDI_ARABIAN[SAUDI ARABIAN DISTRICT]
    SAUDI_ARABIAN --> AL_BATIN_AREA["AL BATIN AREA OFFICE (2)"]
    AL_BATIN_AREA --> AL_BATIN_PROJECT["AL BATIN PROJECT OFFICE * (3)"]
    AL_BATIN_PROJECT --> CONSTRUCTION_DIVISION[CONSTRUCTION DIVISION]
    AL_BATIN_PROJECT --> SUPPORT_RESIDENT[SUPPORT RESIDENT OFFICE]
    AL_BATIN_PROJECT --> A_E_SUPPORT[A/E SUPPORT GROUP]
    AL_BATIN_PROJECT --> COUNSEL[COUNSEL *]
    AL_BATIN_PROJECT --> LIAISON_BRANCH[LIAISON BRANCH *]
    AL_BATIN_PROJECT --> COST_SCHEDULE[COST & SCHEDULE CONTROL *]
    AL_BATIN_PROJECT --> PROGRAM_MANAGEMENT[PROGRAM MANAGEMENT BRANCH *]
    AL_BATIN_PROJECT --> PROPERTY_CONTROL[PROPERTY CONTROL *]
    AL_BATIN_PROJECT --> AUDIT[AUDIT *]
  
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(1) Not assigned to Middle East Division
 (2) Office of KCMC Project Manager
 (3) Office with Liaisons for Project Manager to Rear
 * Located in Berryville, Virginia

Virginia. The MED's Engineering Branch in the Virginia office and its Construction Branch in Riyadh performed most of the planning and coordination for KKMC. Although the Project Manager (Area Engineer) had a dedicated liaison in each of the Division's functional offices, the functional chiefs controlled their staff's work output and priorities.

At this early point in project design and planning, the matrix organization with functional area control was appropriate. Although it had other work in the Kingdom, KKMC was clearly the top priority for MED. All functional areas within the Division were oriented to planning the KKMC project. The Project Manager didn't have to compete with other projects to marshal support for his own. Therefore, he didn't need full control of the project planning elements. The research material from extensive interviews indicates general agreement that this was an effective organization for the project planning stage. However, some key individuals question whether the physical location of some of the Division's elements during this time was appropriate. Section 3.4.3 addresses this issue.

3.4.1.2 ORGANIZATION DURING MOBILIZATION (1977 - 1979)

MED made major organizational changes from late 1977 through early 1978 to supervise Morrison Knudsen Saudi Arabia Consortium's (MKSAC) on-site mobilization as the life/construction support contractor. MED established an organizational objective of strengthening the authority of its project manager without completely dismantling its matrix

organization and functional control.

The major organizational changes made during the mobilization phase of the project were:

1. Replacement of the Area Office for KKMC with a dedicated District Office.
2. Establishment of 2 new area offices: one to administer the life/construction support contract and one for the fixed price contracts.
3. Incorporation of "Management Assistance" personnel provided by MKSAC under CPAF contract into USACE offices.

Middle East Division split the Saudi Arabian District into two elements creating Al Batin District, which was dedicated to the KKMC project. The other, named Riyadh District, handled all other construction projects in the Kingdom. The split also entailed staffing up both districts so that they'd be self supporting.

The creation of Al Batin District accomplished the reorganization's primary objective. It established the District Engineer as the KKMC project manager and strengthened the project manager's authority within the matrix organization. The District Engineer (DE) had more personnel and functions under his direct control than the Area Engineer who preceded him. Most important was MED's transfer of construction functions to the project site under the DE. Al Batin District began moving its operation from Riyadh to KKMC as temporary housing (provided by MKSAC) became available. The entire process took most of 1978 to complete.

Another reason for the DE's appointment as Project

Manager was that MED felt the reaction of the division's engineering and procurement functions to suggestions from the field was too slow./40 Although the DE had no direct authority over the Division's functional chiefs, he had greater stature in the organization than an Area Engineer. His military rank (Colonel) placed him second only to the Division Engineer in the organization. The District Engineer worked directly for the Division Engineer with no intermediate supervisor. Also, the title "District Engineer" carried weight in the organization because USACE's culture places great value on its autonomous operating districts. Thus, MED increased the project manager's influence on its functional chiefs by increasing his status within the organization. In addition, MED increased the project manager's inherent capabilities by placing a competent functional organization under his direct control.

Although the structure was ultimately successful, there wasn't unanimous agreement within MED that forming a district at KKMC was a good organizational move. One senior manager in MED's Construction Division is convinced that MED should have created an area office with a contracting officer at KKMC. He noted that MED added a duplicate organizational layer when it established the District./41 He was not alone in reaching this conclusion. A USACE "lessons learned" study determined that there were "...too many different organizations (division, district, MED Forward, MED Rear); too many organizational layers; too much management."/42 The

District virtually mirrored the Division's functions (with the exception of Personnel Management) and placed additional bureauracracy between the field offices and the engineering function in Berryville, Virginia.

It's debatable whether a district or area office was more appropriate for KKMC. Certainly, there were pros and cons involving either choice. More significant is that MED realized it needed to increase the project manager's influence over the organization's functions when mobilization began. MED strengthened its matrix by creating the Al Batin District and established a base for organizational evolution into the construction phase.

The second organizational change was to establish one Area Office to administer the contract with MKSAC and one to administer all fixed price contracts. These offices had core structures representing most of the functional elements within the District. They had quality assurance, technical review, and contract administration representatives in each office. The Area Engineers were directly responsible to the project manager (DE) for performance on the contracts.

This structure was typical of USACE districts having geographically remote area offices. All work at KKMC was within an 8 kilometer radius, however, so one could argue that the area and district offices created unnecessary duplicate functional layers. Still, there's no information which indicates the duplications inhibited contract management during this phase.

The final major organizational change during the mobilization phase was to incorporate 70 personnel provided by MKSAC under its contract for "Management Assistance" into MED's organization. The assistance personnel were necessary because MED was restricted by manning level ceilings for USACE employees. Since the Corps of Engineers is part of the US Army, Congress limits the number of employees authorized in its civil service workforce. The Corps couldn't provide all of the management personnel needed for KKMC from within the organization because it would cause USACE to exceed its mandated employee ceiling. To compensate for this limitation, MED contracted with MKSAC to provide management assistance. The Management Assistance Group worked under the direction of the Chief, Office Engineering, a section of the District's Construction Division. The group primarily performed support work managing fixed price contracts in 12 functional areas. It also did some planning and scheduling.^{/43} For the most part, the combination of contractor and USACE personnel worked smoothly. From an organizational standpoint, the arrangement was effective.

3.4.1.3 ORGANIZATION DURING CONSTRUCTION (1980-1984)

MED faced a significant reorganization as it entered the heavy construction phase of the KKMC project, particularly in the Al Batin District. During 1980, it established an organization that remained essentially intact until 1984. The following changes comprised the main part of the

reorganization:

1. Attachment of an MED engineering support element to the District at KKMC.
2. Consolidation of functional control of engineering disciplines within the District under the Construction Division.
3. Establishment of 6 resident offices to provide quality assurance for construction contracts under control of the Chief, Construction Division.

Why did MED decide to make major changes to its engineering organization at this stage of the project? Early in the construction phase at KKMC, it became apparent that the separation of engineering (Virginia) and construction (Al Batin, Riyadh) functions would make construction management difficult. The District office had no engineering element and the Division had only a small satellite section in Riyadh. Thus, many engineering and constructability issues had to follow this path to resolution: Field Office (discovery) --> Al Batin District's Construction Division (review) --> MED Forward's Engineering Planning and Liaison Office (review) --> MED Rear's Engineering Division (review, approval) --> Appropriate Architect/Engineer (solution). Engineering solutions followed the same path in reverse. MED Rear centralized decision-making authority in Virginia.

One District Engineer noted that it became tempting for his personnel to solve design problems despite their lack of an integral engineering element. The prevailing attitude was "...let's devise a fix and go on with it. And just don't get Engineering Division involved because they take too long."/44 Of course, this attitude was often counterproductive because

some of the decisions made in the District unwittingly ran against the design intent. Engineering Division countered with equal mistrust when it learned of district-level mistakes, fueling a debilitating we-they relationship./45

The District Engineer pressed the Division to provide an engineering functional element at Al Batin District. He wanted the authority and architect/engineer support at KKMC to make minor design decisions that would be speedy and informed. The DE had only limited success lobbying for engineering representation at KKMC. MED supplied a design group to the District called the AL Batin Engineering Technical Branch. However, it was assigned to MED. This meant that it was only a coordinating element for the District. The project manager (DE) lacked direct control of its efforts. In addition, the Engineering Technical Branch couldn't go directly to A/E firms for problem resolution. First it had to go through the engineering project manager in Virginia. Therefore, although the addition of this branch relieved some of the engineering interface problem, it still fell far short of what the District needed./46

Until late 1979, Al Batin District's Construction Division was a skeleton organization. The DE made a critical organizational decision as dozens of construction contractors mobilized to begin work. He set three objectives for the reorganization:

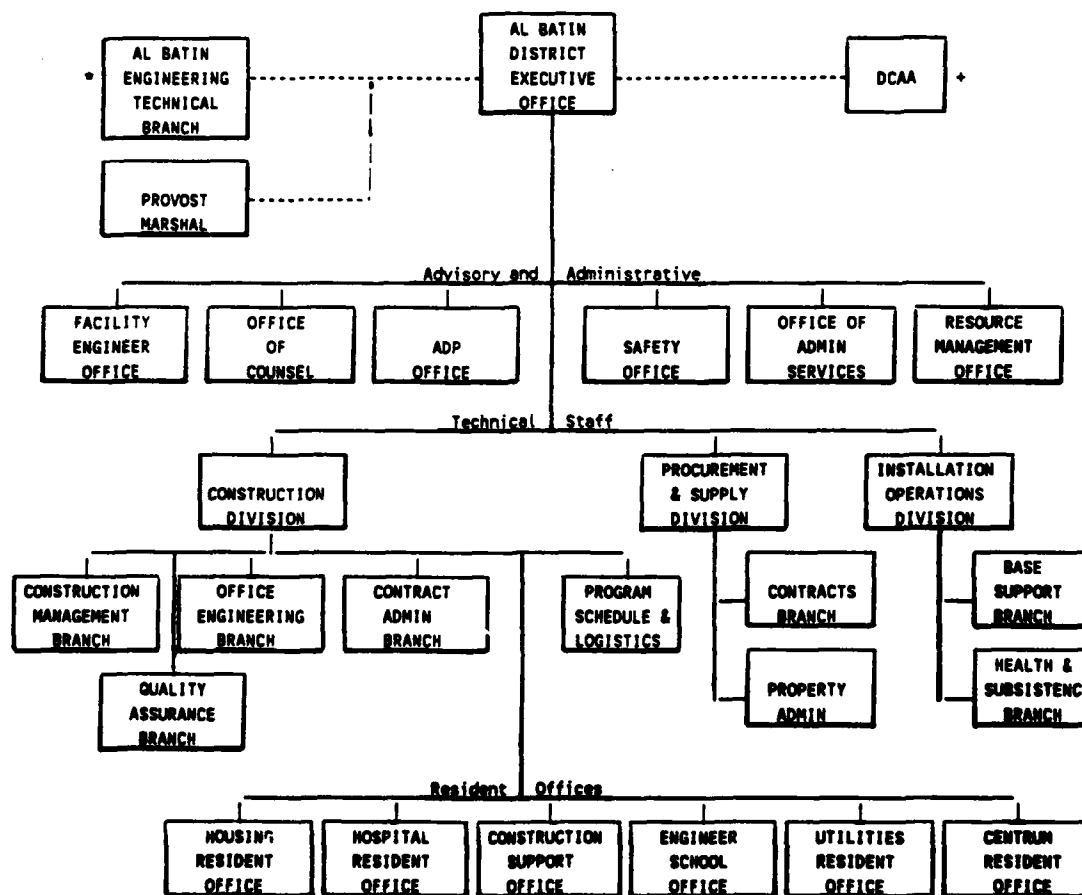
1. Avoid layers and duplication of effort.
2. Organize the District on a functional basis.

3. Facilitate development of control systems to be used throughout construction./47

The Construction Division was the key element in the reorganization. The Chief, Construction Division convinced the DE to centralize control of all construction functions in the Construction Division. The DE delegated responsibility for all construction to the Chief and he organized the section accordingly. Note the Al Batin District's organization during the construction phase shown in Figure 3.6. Construction Division dominates the organization chart with its 5 branches and 6 resident offices. The resident offices replaced the 2 area offices which had existed during the mobilization phase. The Chief, Construction Division stripped the resident offices down so they consisted only of project engineers, construction inspectors and a few clerks or secretaries. He designed the branches to be centralized service groups for the resident offices, but under his functional control./48

This organization eliminated the duplication of functions which existed under the previous area office concept. It also created a matrix organization having strong functional control within the District. Previously, the area engineers, who were project managers in a micro sense, had greater control of the functions. The newly appointed resident engineers now controlled only their inspection staff. They had to coordinate with the Chief, Construction Division for use of his functional assets. However, even though the resident engineers had less control of support

FIGURE 3.6 AL BATIN DISTRICT ORGANIZATION DURING CONSTRUCTION (1983)/49



* Attached from MED Engineering Division.

• Attached from Defense Contract Audit Agency.

functions than their predecessors did, the functional chief had a direct responsibility to support them. This occurred because the Chief, Construction Division was also the resident engineers' first line supervisor. In the old organization, the area engineers worked directly for the DE. After the reorganization, the resident engineers worked for the Chief, Construction Division.

It's clear that Chief, Construction Division became the most powerful position in the District after its reorganization. The DE retained his previous level of control within MED. He remained the KKMC project manager and had a strong subordinate organization but division chiefs at MED still controlled his high-level functional support.

With the exception of a lack of engineering review support at KKMC (a problem that plagued the project manager for the remainder of construction), MED's organization for the project appears to have been appropriate and effective.

3.4.1.4 ORGANIZATION DURING DEMOBILIZATION (1985-1988)

USACE completed its major KKMC construction packages by the end of 1985. As construction wound down, MED planned an organizational phase down with the following objectives:

1. Manage the remaining construction at KKMC with an appropriate organization to respond to customer needs.
2. Consolidate functions to hold down costs and provide centralized direction.

The Al Batin District remained operational until its deactivation in 1985. The Division headquarters moved from

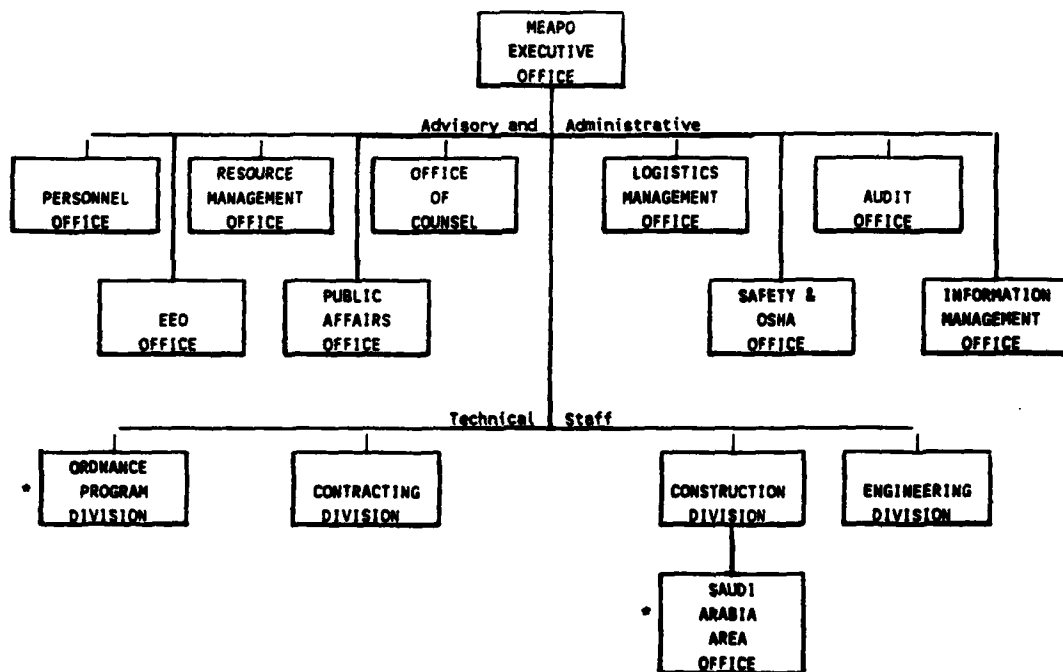
Riyadh to Winchester, Virginia the same year. An Area Office remained at KKMC for another year under the control of Riyadh District. Finally, in 1986 Riyadh District deactivated and MED reorganized into the Middle East/Africa Projects Office (MEAPO) at Winchester. At this point a single area office in Riyadh closed out the remaining work at KKMC, as well as all other programs in the Kingdom. The closeout organization is shown in Figure 3.7.

To summarize the changes made in little more than a year, USACE reorganized a Division with forward and rear offices and two operating districts into a single stateside district-level projects office with one area office in Saudi Arabia./50 USACE completed contract closeout and turnover of facilities to MODA with this organization. It settled the final contract claims and disputes in 1988.

It appears that MED accomplished both of its reorganization objectives. Since it maintained a fully functioning district in Riyadh until 1986, MED had the in-country organization required to respond to all of KKMC's engineering, construction and administration issues. MED eliminated two organizational layers (Al Batin District and MED Forward) and consolidated its functions in the district office at Riyadh and the Division's at Winchester. Ultimately, USACE removed another organizational layer in 1986, when it reorganized into MEAPO and deactivated the Riyadh District.

The reorganization also centralized control in

FIGURE 3.7 MIDDLE EAST/AFRICA PROJECT OFFICE ORGANIZATION/51



* Located in Riyadh, Saudi Arabia.

Winchester. The Area Engineer in Riyadh became the KKMC Project Manager but had virtually no functional control. He had only inspection and limited contracting capability in Saudi Arabia. MEAPO maintained all functional areas in Virginia and the Saudi Arabia Area Engineer (project manager) had no authority over them. In fact, the area office fell under control of MEAPO's Construction Division. Thus, the Area Engineer depended on the Chief, Construction Division to coordinate with the other functional areas at MEAPO for support. (Note: This organization is similar to the one discussed in 3.4.1.3 that was instituted by the Al Batin District for its resident offices.)

It was appropriate to centralize control in Virginia at this point in the project. It massed the organization's capabilities in one location, reducing costs while allowing MEAPO to maintain its capabilities. Work placement at Al Batin was minimal at this point and no longer justified the stationing of construction managers there. Indeed, the only criticisms of the centralization were that it happened too late. Many USACE employees surveyed in 1984 believed that USACE only required an operating division with area offices to complete the project.⁵² This would have entailed centralizing functions at the Division Office in Riyadh and dismantling the Riyadh and Al Batin districts a year earlier (2 years for Riyadh District). Although this option would have been appropriate from an organizational standpoint, it wasn't realistic from a personnel administration point of

view. I'll discuss this further in Section 3.4.4.

3.4.2 ASSIGNMENT OF RESPONSIBILITIES AND AUTHORITY

The Corps of Engineers has developed an organizational culture which values centralized planning and decentralized project execution. This concept stems from USACE's military roots, where centralized planning and decentralized execution have long been battlefield imperatives. Historically, USACE district and area engineers have been given extensive responsibilities and authority to carry out projects in remote areas. It seems that the KKMC project fits this mold perfectly. However, a project study reveals some differences in the authority structure for KKMC when compared to standard USACE practice. In some cases KKMC project personnel had more authority than usual. In others, they lacked authority needed to discharge their responsibilities. The Project Manager shared authority with other commanders and functional staff chiefs because of the unique nature of the mega-project. This portion of the case study examines why this occurred and whether it was appropriate for the mega-project.

It appears that USACE planned a different approach to its responsibility/authority structure from the KKMC project's conceptual stage. As MED established its organization for project planning, it didn't concentrate responsibility and authority in a single location. The following is a summary of the different pockets of authority in the USACE organization during project planning and

execution:

- Director of Military Works, Office of the Chief of Engineers (OCE). Responsible for negotiating and awarding the CPAF contract. OCE involvement required by statute due to contract size exceeding \$1 billion.
- Division Commander, MED. Contracting Officer for contracts and modifications exceeding \$2 million.
- Deputy Division Commander (Rear), MED. Contracting Officer (CO) with equivalent authority to the Division Commander. CO for A/E contracts and early FFP construction contracts.
- Procurement Contracting Officer, Huntsville Division. Responsible for GFE supply contracts.
- District Engineer, Saudi Arabian District (later District Engineer, Al Batin District). In-country contracting officer. Authority up to \$2 million.
- Deputy District Engineer, Saudi Arabian District. Administrative contracting Officer. Same authority as DE, but for off-shore procurement by MKSAC.
- Resident Contracting Officer in Columbia, MD to approve MKSAC procurement.
- Engineer Logistics Command. Responsible for life support procurement and port operations at Ras al Mish'ab. Later, responsible for GFE program.
- Al Batin Area Engineer. Resident Contracting Officer with \$100,000 modification authority. Later, Resident Offices at Al Batin had this authority.
- Chief, Engineering Division, MED (Rear). Responsible for coordinating design contracting and estimating. Essentially, project driver in early years.

Several issues become apparent when examining this list. First, many different USACE offices had responsibilities and authority early in the project. This raises questions about the division of authority and coordination between organizational groups. During the mobilization phase it appears that the Office of the Chief of Engineers (OCE) exercised considerable authority in dealing with the

life/construction support contractor. There's no question that OCE had the authority to be involved as it saw fit. However, it was unusual for OCE to exercise this right on a single contract. OCE's involvement runs counter to the USACE philosophy of decentralized execution.

The Al Batin District Engineer felt that OCE encroached on his authority as the Contracting Officer for the MKSAC contract. OCE second-guessed several decisions the DE made to get MKSAC moving on the job. MKSAC had a direct line of communication with OCE from its Columbia, MD office and used it when the consortium disagreed with the DE's directives. OCE often pressured the DE to "cooperate" with MKSAC. During August 1978, OCE representatives visited Al Batin and inquired about the DE's fitness to command.

Two aspects of this situation were disturbing. The first was OCE's extremely close relationship to the contractor. It's evident that the Chief of Engineers had a personal stake in MKSAC's success because he'd been influential in selecting both the contractor and the controversial contract type (CPAF) used. He couldn't believe that Morrison Knudsen's performance was less than outstanding because of the company's exceptional work in Vietnam and on other USACE projects. He seemed to have an attitude that "MKSAC knows best" without knowing the circumstances.

The other disturbing aspect of this situation was that OCE ignored its traditions of decentralized execution and chain of command. Al Batin District was two command levels

removed from OCE. The MED Division Engineer worked for the Chief of Engineers but OCE ignored its division management level and dealt directly with the district. Thus, OCE usurped the authority of a district engineer without consulting his commander. The MED Division Engineer finally rectified the problem by expressing confidence in his district engineer to OCE and requesting that the Chief's Office stay out of the project's management./53 OCE involvement in the contract was negligible thereafter and MED restored decentralized project control.

Another question stemming from having several USACE offices share responsibility and authority is whether the authority was clearly divided and appropriately coordinated. For the most part, MED successfully split responsibilities and authority between its office in Riyadh, its office in Virginia and its field office at Al Batin. However, MED ran into problems when organizing for procuring government furnished equipment. USACE enlisted the Huntsville Division to assist MED in procurement because most government furnished equipment came from the US and Huntsville had an established procurement network. The relationship with Huntsville Division posed a problem because MED had no command authority over it. The Division failed to assign a dedicated GFE program manager. In addition, the Engineer Logistics Command initially had no involvement with GFE. With no clear chain of responsibility and authority, the GFE program foundered. The majority of USACE employees surveyed

by the Engineer Studies Center maintained that MED's procurement program would have been more successful if it had formed its own logistics branch at the beginning of the project (ELC didn't pick up the mission until 1979)./54

The second major issue evident from the levels of authority summarized above is that many USACE employees with significant contracting authority were in different locations. This raises a similar question to the first but on a personal level. Were there clear divisions of responsibility and authority between commanders and their subordinates with contracting powers? Was there coordination between individuals with authority on the same project?

MED did a good job breaking down specific responsibilities and authority for its contracting officers. Each contracting officer received written directions spelling out the limits of his responsibility and authority. One noteworthy difficulty, however, was an occasional mixing of authority between the Al Batin District Engineer (the Contracting Officer) and his deputy on the MKSAC contract. The Deputy District Engineer had Administrative Contracting Officer (ACO) authority for MKSAC. The assignment of a CO and ACO on the same project was rare because it gave them virtually the same authority at the same time. It was necessary because a USACE representative had to approve all major procurement requests by MKSAC. The contractor had procurement offices in Saudi Arabia, the United States and Holland. Since the Contracting Officer couldn't be in these

locations at the same time, his deputy had to travel constantly. He needed contracting officer authority to do his job. The District Engineer and his deputy never successfully delineated this authority, although they tried. As a result, on several occasions they approved procurement of similar items at different sites or failed to take action on procurement requests, each thinking the other would do it./55 Although this inefficiency added to costs and confusion, it wasn't a critical problem and it disappeared with completion of the MKSAC contract in late 1980.

The third major management issue evident from the summary of authority originated from MED's assignment of its Engineering Division as the project's driving force. The Chief, Engineering Division may have been the most important individual in the KKMC project. He was the Program Manager for all of MED's Saudi Arabian work and had considerable responsibility for KKMC during construction design and award. Once construction began, however, he had little designated responsibility (other than for his functional staff) and he didn't work for the Project Manager (the Al Batin District Engineer). Yet he retained the authority to approve and coordinate all requests for changes (even those for constructability) from the field. In addition, Engineering Division had no representatives in Saudi Arabia early in the project and only a few later on. How did USACE reconcile the obvious responsibility, coordination and authority difficulties?

In reality, the issue never was satisfactorily resolved. The Engineer Studies Center concluded that the geographical separation between Engineering and Construction Divisions caused:

- Change order delays.
- Misunderstanding of issues faced at both locations.
- Communications difficulties and a lack of responsiveness.
- A "we - they" situation between the rear and the field locations./56

This arrangement also left the KKMC Project Manager with full responsibility for project completion but no authority over the engineering function. On the positive side, centralizing engineering authority in the rear resulted in administrative cost savings, fully coordinated design changes and reduced owner influence in determining suppliers and contractors.

MED attempted to relieve the negative effects by adding an engineering element to its Riyadh office (including its Engineering Technical Branch at KKMC) in 1980. This improved communications and coordination but did nothing to change the authority and responsibility structure. Engineering Division retained centralized authority despite USACE's cultural norm of decentralizing execution. As a result, engineering response to construction developments remained slow throughout the project.

To summarize the preceding section, USACE generally followed its standards for centralizing planning and decentralizing execution during the KKMC project. When it

did stray from its normal responsibility/authority structures, such as in centralizing the engineering function, it had supporting rationale. However, it's not clear that the advantages offered by departing from the norm outweighed the disadvantages they caused. I conclude from this study that USACE proved its policy of centralized planning and decentralized execution can be successfully applied to mega-projects.

3.4.3 STAFF LOCATIONS AND EFFECTIVENESS

In the preceding two sections, I briefly addressed the issue of where to locate staffs working on KKMC for optimal results from organizational and authority perspectives. Now I'll examine the other considerations influencing location choice and evaluate USACE's decisions.

MED made four key staff location decisions that affected performance on the KKMC project. They're listed below:

- MED decided to locate its Engineering division at its Rear office in Virginia.
- MED arranged with Huntsville Division to locate a procurement group in the United States to control Government Furnished Equipment for the early stages of the project.
- MED located its Division Forward office in the same building in Riyadh as one of its districts.
- MED decided to locate a complete district organization at KKMC (Al Batin District) for the sole purpose of building the city.

The overriding consideration in choosing the locations of Engineering Division and the procurement group was cost. At the time Saudi Arabia suffered from double digit inflation

and a shortage of local labor and materials industries. USACE feared that locating its entire staff in the Kingdom would invite rapid cost escalations for its services. A USACE project planner explained,

"The Corps' position was that, if you could do it outside the country, even with some reduced efficiency, you...would be better off doing that given what it would cost in-country [versus] out-of-country." /57

Although cost reduction was the predominant factor behind the USACE decision to locate engineering and procurement in the US, it wasn't the only one. Other considerations included: the Saudis requested US designs; it benefitted the US economy to procure American equipment and supplies; and the distance was too great between CONUS and Saudi Arabia to justify locating engineering and procurement forward when they were dealing with US companies. /58 In the final analysis, it's not evident that locating these two staff elements in the US accomplished its goal of cost reduction. There's not enough statistical evidence to prove that the absence of engineering and procurement on site led to significantly increased direct project costs. However, there's also little proof to an assertion that it reduced management costs. MED exceeded its goal of an 8% Supervision and Administration (S&A) rate during the life of the project despite engineering and procurement's stateside stationing. It also absorbed construction delay costs that were caused, at least in part, by slow responses to necessary design changes by CONUS-based engineers. I conclude from this analysis that, as a minimum, a small engineering group with

authority and representatives from A/E firms should have been located on site from the beginning.

MED's decision to locate the Division Forward's office and one district office (Riyadh District) in the same building complex is questionable for the opposite reason. In this case the Division created an unnecessary additional functional layer, with its accompanying high cost. Critics of the arrangement claim that the Saudi Arabian program could have been completed in either of two ways: (1) With the entire Division organization in the US and autonomous districts in the Kingdom; or (2) With a single, operating division in Saudi Arabia and a series of area offices. I should point out that the Division's location wasn't unreasonable during the prime construction years at KKMC because the Al Batin District was 450 kilometers from Riyadh. However, KKMC experienced a duplication of staff functions at the beginning and end of the project when it was controlled by the district in Riyadh. Since one of MED's goals was to minimize S&A costs, it's difficult to justify a stationing decision that created duplicate layers of costly engineers and managers. It seems that either of the two alternative stationing proposals would have been adequate for the project while reducing confusion and costs.

The final stationing decision listed at the beginning of this section, that of locating a district organization at KKMC, was the most effective. It's unusual to dedicate an entire Corps of Engineers district organization to complete a

single project within a small geographic area. However, USACE made an exception for KKMC because of the sheer magnitude of the effort. The functional staff requirements for this project far exceeded the capabilities of a resident or area office. MED understood that the Project Manager needed a large, responsive organization on site. Therefore, MED staffed a district office at KKMC despite the high costs involved. In this case, it appears that USACE received a high return on its investment.

In conclusion, out of the dozens of stationing decisions made by MED over the life of the KKMC project, four stand out as risky and worthy of study. The locations that MED chose contributed to the project's successful completion but they came at a price. Although MED facilitated engineering, design and procurement by locating those sections in the US, it forfeited effective engineering-construction coordination on site. In addition, there's no evidence that MED reduced its S&A costs by keeping engineering and procurement in the US. Conversely, it's evident that MED increased its costs by collocating its Division (Forward) and Riyadh District offices. It may also have reduced efficiency by creating overlapping functional layers. Finally, MED's decision to station a district office at KKMC during the construction phase was critical to the project's success. It provided the Project Manager the expertise (except engineering) and power he needed to keep construction on schedule. Despite their drawbacks, MED's stationing decisions were integral to the

KKMC project's success.

3.4.4 PERSONNEL DECISIONS AND EFFECT ON STAFFING

During 1983, the peak work placement year for the entire Saudi Arabian Program, MED's workforce topped 1300 employees. Of this total, 362 were assigned to Al Batin District and at least 150 more worked on the KKMC project in the Division Forward and Rear Offices and in the ELC./59 The requirement to build a large, highly qualified workforce to execute a huge but finite program raises some questions. How did MED attract the large number of government service employees needed to manage this project? What were the human resource policies MED employed to support the workforce? How did MED handle the build up and draw down? Was its human resource strategy successful? In this section, I'll answer the questions raised by MED's manning requirements.

The first challenge faced by MED personnel managers was to create incentives to attract qualified personnel. The living conditions in Saudi Arabia were primitive early in the project. To complicate matters, there was virtually nothing on the ground at KKMC to attract employees. Therefore, Personnel Division advertised KKMC based on a combination of pay and adventure. It targeted the, "...hard core of people in the Corps who would go anywhere that's interesting, where there's a challenge. Those are the kind of people we brought over in the early days."/60

Good pay was the greatest attraction early in the

project. The pay was based on standard US Government civil service scales but MED improved it in several ways. First, almost all employees received a promotion to go to Saudi Arabia. Thereafter, they were encouraged to stay by the promise of rapid promotions. Second, employees had an additional incentive to increase income because there were no limitations placed on the amount of overtime they could work. USACE employees who were accustomed to strict limits on overtime in CONUS districts saw the opportunity to double take home pay by working in Saudi Arabia. Another pay incentive was time-and-a-quarter rates for Sunday work even though Sunday was part of the five day work week in Saudi Arabia (Thursday/Friday is the weekend in the Moslem Kingdom). Accompanied employees received a Post Differential at 20% of salary (taxable). MED provided a Separate Maintenance Allowance for the families of workers on mandatory unaccompanied tours. All employees received a Cost of Living Allowance based on location, salary and number of dependents./61 These pay incentives enabled many USACE field representatives (construction inspectors) to draw the maximum pay authorized by law for grade scale employees.

The pay incentives were sufficient to attract the core of experienced USACE employees needed to get the project off the ground. However, MED had to develop a more attractive package of incentives and life support to attract and keep a workforce during its build up for peak construction.

By early 1979, Al Batin District had enough life support

in place at KKMC to support its growing workforce. MED recruited its engineering and management staff from the United States. Since USACE lacked sufficient mobile human resources to staff the KKMC organization from other districts, the incentive package had to attract employees from private firms and other government organizations. Recruiting from foreign countries was minimal and usually for low pay grades. MED developed the following benefits and support activities in addition to pay incentives:

- **Accompanied Tours.** All employees at grade GS-8 or higher were authorized accompanied tours at KKMC (GS-12 and above in other parts of the Kingdom). Accompanied tour length was 24 months, unaccompanied 12 months.
- **Housing.** Fully furnished villas, apartments and trailers provided at no charge. Utilities were free.
- **Transportation.** Male employees were issued a car, maintenance, fuel and insurance at no cost. Used for both business and personal reasons. Females provided free bus and taxi.
- **Commissary and Post Exchange.** Refrigerated truck brought food orders once a week. Pork was available from the commissary but not advertised because Saudi religious laws prohibit its sale on the open market. Small post exchange at KKMC. Employees authorized a liquor ration (also not advertised due to Saudi sensitivity).
- **Medical and Dental.** Free routine dental work and 100 bed hospital at KKMC.
- **Schools.** Kindergarden through 9th grade American school at KKMC. Free tuition for high school children attending Department of Defense schools in Europe. Free transportation for home visits during the school year.
- **Environmental Morale Travel (EMT).** Each employee and dependent living in Saudi Arabia authorized the cost of a round trip airline ticket from Riyadh to London (or equivalent amount applied to a different destination) for each year of employment in Saudi

Arabia.

- **Dining Facilities.** Subsidized contractor-operated family dining facility at KKMC.
- **Recreation.** KKMC had a movie room, indoor games, tennis, basketball, volleyball, outdoor pool, video room, library, weightlifting room and craft shop./62

This was a generous pay and benefits package for government employees by any standard, yet MED had difficulty staffing up quickly enough at KKMC to match the pace of construction. The first Al Batin District Engineer explained that he couldn't fill key positions fast enough because he lacked candidates. The DE preferred to choose from 2 or 3 candidates per position but he often received only one./63 USACE lacked a sufficient number of mobile personnel to staff the project from internal resources. As a result, MED recruited a large number of people who had no experience with the USACE management system. Despite the lack of aspirants for key jobs and training time required for employees with no USACE experience, MED managers interviewed for this study concurred that they received high-quality personnel.

Slow personnel recruitment became a critical problem in 1980, when Al Batin District lost the 70-man Management Assistance Group provided by MKSAC under its CPAF contract. The District was unprepared to take over the construction management role that the Management Assistance Group had filled. The MED Commander authorized Al Batin District to contract for 35 temporary consultants under Title II of the US Code to compensate for the loss of its MKSAC workers. These consultants worked in contract administration,

estimating and technical review and were an essential part of the organization until MED recruited permanent personnel. Word spread of good living and working conditions in Saudi Arabia by 1982 and MED's recruitment success improved. In addition, KKMC stabilized its workforce because a significant percentage of its employees extended their original 2-year contracts. Within three years, Al Batin District had sufficient staff to close out its Title II contracts entirely./64

MED faced a completely different personnel challenge during the demobilization phase. It had a large number of employees working in jobs at pay grades one to two levels above comparable positions in the US. Ultimately, it had to outplace all but a handful of its employees over a three year period. To compound its problem, personnel from government organizations came to Saudi Arabia with the promise of reemployment after job completion. Employees from Department of Defense (DOD) activities had statutory reemployment rights with the activities that released them to go overseas. Other employees could enroll in the DOD Priority Placement Program, which offered them assistance in obtaining positions in CONUS at or near their overseas grade./65 Reemployment promises were easier to make than keep and Personnel Division struggled to meet its obligations. In the end, though, MED's outplacement program was successful and it helped settle many employees with valuable mega-project training into DOD agencies. Some USACE offices, particularly in Arizona, New

Mexico and California, obtained a number of employees with experience at Al Batin./66

The most criticized aspects of MED's personnel policies involved short tours for military officers in key positions and the high percentage of accompanied tours. Military personnel managers were more concerned with the officers' personal development than with project continuity. Most of the lower ranking military officers had unaccompanied one year tours. Officers assigned to key positions had two year accompanied tours but virtually no opportunity to extend because of negative career effects. Army personnel policies stress high mobility and short tour length. Those who stay in the same job for more than two years are often suspected of "Homesteading" and suffer negative career consequences. As a result, MED had 4 Division Engineers and 4 District Engineers at Al Batin during the 7 most important years of the project (1978 -1984). This meant that MED lacked continuity in its most critical positions and suffered the consequences of each new key officer's learning curve. Although there's general agreement that the officers were competent, short tours limited their opportunities to contribute and created a lack of continuity at the top.

Criticism of accompanied tours revolved around their high cost. The critics felt that MED should have reduced expenses by limiting accompanied tours to top-level managers, since the estimated cost of moving and supporting a family was \$100,000. Accompanied tours clearly drove up

MED's Supervision and Administration costs but I'm convinced that the generous policy was necessary. As it was, MED had a difficult time recruiting sufficient personnel for the project. Al Batin was a particularly difficult place to be without a family because it was so remote. MED's policy of offering accompanied tours to lower-level employees helped attract and retain many well qualified people who wouldn't have participated otherwise.

In summary, MED's personnel staffing plan worked well despite Federal Government restrictions placed on the process. The Personnel Division developed an imaginative package of pay and benefits and displayed loyalty to its employees by working to outplace them into good jobs. As a result, MED attracted the employees they needed to do the job. It also effectively used Title II consultants to plug recruiting gaps. Even its questionable policies offered undeniable benefits. Only the rigid military officer assignment policy for key positions (which MED didn't control) appears ill advised. Overall, MED provided effective personnel staffing and support of the KKMC project.

3.4.5 MANAGEMENT COSTS

Despite MODA's huge construction budget during the oil boom of the late 1970s, it was extremely concerned about keeping project costs down. Cost control was one of the reasons the Saudis wanted USACE to manage its military construction program. Since USACE lacked the profit motive

that drives private companies, MODA counted on the Corps to save money on construction management. It placed constant pressure on MED to minimize management costs, eventually directing that its charges not exceed 8% of the program's construction placement direct costs./67 This section concentrates on the sources of MED's Supervision and Administration (S&A) costs and the effectiveness of MED's efforts to control them.

Under the Engineer Assistance Agreement, MED charged all costs of operations which were relatable to KKMC construction to the S&A account. This included all direct costs incurred by MED's construction field elements for Supervision and Inspection (S&I) plus the portion of overhead which applied to KKMC construction. Specifically, these charges included:

- **Personnel.** Salaries and benefits for all MED employees working for KKMC.
- **Travel.** Transportation, per diem and miscellaneous costs for MED personnel on KKMC construction-related travel.
- **Contractual Services.** Payments to commercial firms and other USACE districts doing work for KKMC.
- **Amortization of Capital Assets.** End items > \$1000 with a useful life > 1 year were expensed over the life of the item. Includes vehicles, leased offices and housing, ADP equipment, communications equipment and furniture.
- **Other.** Includes transportation charges, supplies and materials, MED dependent education, printing and communications services./68

MED design management expenses weren't charged against the S&A rate. Instead, they were added to design contract costs and charged under a line item called "Engineering and

Design". E&D costs were 3% of total project costs. However MED design supervision costs weren't split out from its contracts to be scrutinized by MODA. Instead, the S&A rate received the Saudi's cost-control attention.

It's difficult to separate KKMC's S&A costs and actions taken to control them from other projects in Saudi Arabia because MED's bookkeeping and control strategies were done at program, not project level. Prior to 1976, S&A costs were charged directly to each Saudi project. When the KKMC project began, however, MED decided to track S&A against the entire Saudi program. This worked as a cost-control measure in itself because it required fewer accountants. MED then charged S&A to each project as a flat percentage of direct construction costs. Therefore, it's impossible to identify exactly what S&A costs applied to KKMC and, conversely, what measures were taken to reduce S&A for the military city. Instead, I'll refer to costs and action taken to reduce them across the entire Saudi program.

The major sources of S&A cost were personnel expenses (including pay and benefits), life support contracts and construction management service contracts. Long term housing leases were a large S&A expense in other areas of the Kingdom but not at Al Batin. MED built its own housing at KKMC or leased trailers for shorter periods since there was no existing housing available.

During the first three years of the project (1976 - 1979), S&A charges were 8.9% of construction placement costs.

MODA felt the costs were too high and directed a reduction to 8%. MED saved some money by sub-leasing facilities in other parts of the country when they were no longer needed. However, the Division never made a strong effort to reduce costs in the most expensive S&A area - personnel. MED couldn't save costs by reducing the size of its expensive in-country management force because it was actually shorthanded. Still, there were two areas where MED could have reduced personnel costs. One was by removing some of the duplicate functional staff at district and division offices. This was unsuccessful due to a combination of office politics (disagreements over what positions were expendable) and contractual requirements to provide jobs to those who'd been recruited. The other savings option was to cut back benefit packages for employees in Saudi Arabia. The Division did close some commissaries and exchanges during the demobilization period. However, MED discovered that once it provided benefits they were almost impossible to take away without causing serious morale problems./69

In the final analysis, MED made no sweeping policy changes to reduce its S&A costs. As a result, it didn't significantly lower them even after the MODA directive. It's likely that the S&A rate for KKMC would have been under 8% if the Division had calculated it separately. I attribute this to the high rate of placement in a small geographical area with a compressed time table. These project features weren't as applicable to many of the other projects in the Kingdom.

At any rate, MED's S&A costs hovered slightly above the 8% mandate during the prime construction years of 1980-1983./70 The S&A rates for the final project years were unavailable but probably higher.

The conclusion I draw from MED's S&A experience is that, once the KKMC planners decided how to staff the project and support its employees it was very difficult for the government organization to change. MED could rapidly adjust its management procedures to construction plan changes but not its personnel procedures, due to government regulations. Since the Kingdom's construction program became slightly smaller and advanced more slowly than planned, the personnel costs became higher per direct construction dollar. This pushed the S&A rate up. Still, MED could have lowered its S&A costs by creating flexible personnel procedures and eliminating functional duplication between the Division and its districts. Its 8% S&A rate wasn't unreasonable but more flexible personnel planning could have improved it.

3.5 PROJECT CONTROL

In December 1977, the MED Commander asked the Engineer Studies Center to develop an automated control system based in network analysis and having three capabilities:

1. Ability to display interdependence among various components of the MED program and assessing the impacts of change in one area upon the others.
2. Equipped with an alarm system to identify potential problem areas and flag them for remedial action at the appropriate level of management.
3. A "control room" for monitoring the MED program at the executive level of MED management./71

It's interesting to note that, despite USACE's previous mega-project experience, the organization lacked a standard tool for controlling huge military construction projects. However, the Engineer Studies Center felt that the pieces of an effective project control system already existed within MED and only needed to be collated and extended. In this portion of the case study, I'll critique the systems that MED developed to control costs and schedule on its KKMC project. I'll examine MED's control systems at the program and individual contract levels to determine whether there was continuity from the Division Headquarters through the District to its Resident Offices. I'll also study KKMC's disputes history, peculiarities it found in managing international contractors, its GFE control efforts and project life cycle management.

3.5.1 CONTROL SYSTEMS

The two greatest management challenges that MED faced on

the KKMC project were controlling costs to stay within budget and controlling schedule to ensure the project was completed on time. There's nothing unique about the need to control these areas. Managers of projects of any size have to concentrate on cost and schedule control. The challenge for this mega-project was to develop systems that could process large volumes of information, then respond quickly to user commands to produce timely alternatives for cost and schedule control actions. The systems had to be based on up-to-date data that was easy to obtain and program. Their products had to be simple so that managers could digest and use the information to make decisions. Finally, construction managers on site needed access and input to the systems. The next two sections evaluate the systems used by MED to control costs and schedule for the KKMC project.

3.5.1.1 COST CONTROL

The success of MED's cost control efforts for the KKMC project hinged on controlling the life/construction support contractor's spending. Unfortunately, the Division had little success holding it down. MED didn't have a control system in place at the start of the contract. Due to the speed and enormity of required expenditures, spending snowballed and MED never caught up. There's evidence that MKSAC overbought materials and equipment, lost and accidentally destroyed material through poor accounting and storage procedures and overstaffed its contract. These factors acted

together to significantly exceed projected costs. Soon the contract with MKSAC was in disarray. What caused this problem? Why didn't MED have a control system in place when its criticality appears obvious?

The control problem was threefold. First, MED required the contractor to comply with cost and control criteria that both organizations were unfamiliar with. The contract that MED negotiated with MKSAC called for the contractor to validate the "Cost/Schedule Control System Criteria", or CS2, which was prescribed under the Armed Services Procurement Regulations. MED intended for MKSAC to comply with CS2 to provide an approved government accounting, documentation control and contract administration system.^{/72} However, neither MED nor MKSAC had any prior experience with CS2. The system had been developed to control costs on major weapons development and procurement programs and hadn't been applied previously to support construction procurement. In its most basic form, CS2:

1. Ties budgeting and scheduling together so that management performance and accountability can be readily traced from the total project to finite work elements in a comprehensive Work Breakdown Structure.
2. Time and dollars are placed against each work Work Breakdown Structure and responsible managers are identified.
3. Various levels of aggregation and acceptable variances in cost and schedule are reviewed regularly at corresponding levels of management.
4. Necessary and timely adjustments can be made to ensure successful performance in critical areas.^{/73}

Although MKSAC (through a subcontractor) had given an

impressive presentation to USACE during contract negotiations on how it would implement CS2, it had made no real attempt to work out the details of the system. The contractor actually started out with Morrison Knudsen's normal accounting system but ended up changing it in the process of trying to get validated for CS2. The system never was validated during the 3-year contract./74 MED couldn't get control of the system because it had no experience with CS2 and didn't recruit contract administrators who did. The Division couldn't push its contractor in the right direction because it didn't know, itself.

The second problem which contributed to MED's loss of cost control was that it understaffed MKSAC contract supervision, particularly at the beginning. For example, MED used personnel from The Defense Contract Audit Agency (DCAA) to act as cost watchdogs. Yet, the first DCAA auditors didn't arrive on site until August 1978 - six months after MKSAC began staffing and procuring./75 MED's own contract administration staff was shorthanded and unable to track material procurement, arrival and storage actions. As a result, MKSAC overbought material and equipment, lost accountability for some of it and destroyed a significant amount through improper storage procedures. All of these actions led to increased procurement costs.

The third issue at the root of the cost control problem was an early lack of ADP equipment on site. Effective computer support was absolutely necessary to make any cost

control system work. However, neither MKSAC nor MED procured sufficient, compatible ADP equipment or software before starting operations in Saudi Arabia. MKSAC's initial order for its computer system was incorrect. The contractor then had to time-share with another firm for several months while it waited for its new computer system to clear bureaucratic channels. By the time both organizations had dedicated computers on line in Saudi Arabia, the system was out of control. MED never recovered cost control on MKSAC's contract.

3.5.1.2 SCHEDULE CONTROL

MED had different experiences in controlling schedules at the macro (project) and micro (contract) levels. The Division adopted a computerized hybrid of existing USACE schedule control systems to track progress and identify alternative courses of action at the project level. The system was designed to allow the Division Rear to shepherd the project from the concept through the design phases until construction was underway. At that point, the Project Manager was expected to control the construction schedule through individual, contractor-developed CPM systems.^{/76} In this section, I'll evaluate the effectiveness of MED's 2-tiered approach to schedule control.

The cornerstone of MED Rear's schedule control was its development of a computer system which combined Resource Allocation/Project Management (RA/PM) with existing USACE

reporting systems. MED recognized that its existing data base reporting system lacked flexibility. The Engineering Project Manager had difficulty evaluating scheduling alternatives when key milestones were missed. He was forced to fix the milestones and hope there was slack in the schedule to compensate for slippages. MED required a system that was:

- In-House
- Network Based
- Automated
- Capable of CPM Scheduling, Management Reporting and Gaming/77

MED required a network-based system because it was USACE policy for both internal managers and contractors to use one. The Engineer Studies Center recommended that MED use RA/PM after studying several in-house and commercially available network-based systems. RA/PM met all of MED's requirements and could use the existing data base. It offered the most advantages and fewest drawbacks of any system considered. The system hadn't been used on USACE military construction projects in the past but it had been successful on some large civil works projects.

MED ultimately created a hybrid, "... disciplined configuration management control system which baselined design and tracked changes and adjustments, thereby allowing visibility of the project cost and time impacts" throughout the design phase. It proved to be an effective system, though not particularly user-friendly. One Division Rear

Commander felt it was the most successful construction management technique used during the project./78

One problem with the configuration management system was that it was unavailable to the Project Manager in Saudi Arabia. The District Engineer had no direct access to the system since it was located in the rear. In addition, the configuration management system wasn't intended to control the construction phase. This created the second tier of schedule control that I mentioned earlier. The Al Batin District had automation capability after MKSAC finally procured its system. By 1980 the District had a central control monitoring system that covered every contract. The District's Construction Division was the primary user. The computer program had many specialty features but interface problems limited its usefulness./79 Construction Division anticipated a need to program construction support requirements across contract packages for the peak construction years. It had to determine gross amounts of aggregate, cement, precast concrete, asphalt and other government furnished materials for each contract. The Chief, Construction Division described how the District developed a master integrated network to help identify the requirements:

"...this involved a very large effort in trying to break the requirements of the total city down. We could never get down to a building basis. It just made it too big and too unmanageable, but we did get down to...a module basis - like a group of 78 houses where you have 1750 in one housing contract."/80

This network was a successful tool in the District's efforts to project and control the schedule.

On the other hand, managers for individual construction contracts had no access to automated schedule control. One of the Resident Engineers at KKMC described the reality of schedule control at contract level this way:

"I think our real [control] tool was a one page bar chart. We probably heard a little bit about master NAS but, in reality, for the working folks out there, I don't think it was ever really utilized."/81

Most of the construction contractors had automated NAS capability but were uncomfortable using CPM, which was required under Special Provision 4 (SP4) of their contracts. Al Batin District's Resident Engineers were often equally uncomfortable. SP4 didn't limit the size of the required CPMs and the contractors' automated systems often produced unwieldy printouts which managers couldn't digest. One District Engineer described a typical CPM horror story. A contractor with a \$200 million contract for 15 facilities lasting 2 to 3 years brought a printout with 45,000 activities to the Resident Engineer for approval. The Resident Engineer couldn't realistically review it and neither he nor the contractor could use it as a management tool./82 This story was more the rule than the exception on the KKMC project. As a result, both the contractors and MED contract administrators tended to control schedules with simple bar charts, as described earlier.

MED controlled KKMC's project schedule effectively despite its low level of sophistication at project level and the significant disparity in scheduling capabilities between its rear and forward offices. The configuration management

system worked well for managing engineering, design and contract award schedules. However, the Al Batin District had to create a completely separate schedule control system because configuration management wasn't integrated overseas. In addition, it failed to validate CPM use at the contract level. Although MED successfully controlled the project schedule, it could have gone farther during planning toward developing a single system which could be used everywhere. Instead, managers at all levels had to spend much valuable time developing their own systems. At the contract level, I'm inclined to attribute MED's schedule control success more to its project managers' experience than to its CPM control systems design.

3.5.2 CONTRACTING

Once construction began at KKMC, project focus shifted from planning and design to construction contract management. MED concentrated project responsibility and authority with the Al Batin District Engineer. He became the Contracting Officer for all construction contracts and the Successor Contracting Officer of MKSAC's life/construction support contract.

In this section, I'll examine the aspects of contracting which had the largest impact on the KKMC mega-project. These issues are: Al Batin District's Contract Management effectiveness for its cost plus award fee (CPAF) contract with MKSAC and for its firm fixed price (FFP) construction

contractors; its methods for reducing and success in resolving contract disputes; and its approach for dealing with the unique management challenges posed by contracting with international firms.

I don't address MED's engineering contract administration here because there was nothing unique about their contract structure that contributes to the study of mega-projects. This shouldn't suggest, however, that effective engineering contract management isn't critical to mega-project success. On the contrary, it was crucial to this project. I pointed this out in the preceding section on systems used at MED Rear to control cost and schedule throughout the design stage.

3.5.2.1 CONTRACT MANAGEMENT

During the master planning phase of project planning, MED received MODA's approval to use two types of contracts for its construction program - cost plus award fee (CPAF) and firm fixed price (FFP). The Saudis limited CPAF contract use to the life/construction support contract with MKSAC. All construction contracts were FFP.

The decision to use a CPAF contract for life/construction support involved significant risks for both MED and its Saudi client. First, the goal of using a contractor to provide life/construction support was to reduce risks for construction contractors (see Section 3.3.3). Second, the choice of a CPAF contract for this

purpose meant that MODA absorbed all of the risks that it removed from the construction contracts. MED attempted to build performance incentives into its agreement with the support contractor (MKSAC). USACE selected the MKSAC consortium after reviewing its written and oral presentation against one by Brown and Root. The winner negotiated a target cost on a 3-year contract with USACE, a base fee at 3% of costs and an award fee at a maximum 3%, based on periodic MED performance appraisals. Thus, with the exception of its award fee (potentially \$30 million on a \$1 billion contract), MKSAC had virtually no risk of its own. MODA would completely bear costs resulting from MKSAC's mistakes. In return for accepting this risk, MODA stood to save money in its FFP construction contracts because bidders would reduce their contingency fees.

This was a difficult concept for MED to sell to its client. The Saudis feared the possibility of severe cost escalation in a CPAF contract. They were more inclined to accept higher FFP contract bids because the costs could be understood and budgeted up front. Initially, MED attempted to convince MODA to approve of a single CPAF contract to construct the entire city./83 MODA rejected the concept. The Saudis ultimately agreed to a CPAF contract for life/construction support after continued urging by MED, but they continued to have misgivings about the concept.

CPAF contracting was also risky for MED. Virtually all of MED's previous construction in Saudi Arabia was under FFP

contracts. In addition, USACE employees had little cost-plus contracting experience because US Government construction regulations mandate FFP contracting. Therefore, MED lacked a base of construction managers with knowledge of CPAF contract administration procedures. If MED failed to administer the contract properly, it could lose credibility with its client, drive up construction costs and lose control of the schedule.

Unfortunately, the CPAF contract was poorly executed and some of these fears came true. As I discussed in Section 3.5.1.1, MKSAC never established the computerized cost and schedule control system for procurement that was required by the contract. This caused serious cost overruns and some schedule slippage. However, there were two other factors which made equal contributions to the problem.

The first problem was that the contractor (MKSAC) didn't put the quality of personnel and effort into the contract that it promised during contract negotiations. The Project Manager (District Engineer) noted :

"It was apparent after the first month that MK was staging it very slowly and had not brought good people aboard, and they really weren't jumping into this thing as fast as they indicated they would be able to do it."/84

After a weak start, MKSAC never recovered in the fast-paced construction environment. It was generally acknowledged that Morrison Knudsen's consortium partners, Fischbach and Moore and Interbetton did a professional job on their portions of the contract. Morrison Knudsen, however, spun its wheels throughout the project. MKSAC tried to overstaff the job

and generally didn't use its top managers to get on track./85

The second problem was that MED didn't staff up quickly enough and recruit sufficient personnel with CPAF experience to manage MKSAC back onto track. One key MED manager noted:

"...the staffing seriously lagged start-up demands; i.e. the contract was well under way before the civilian personnel system could respond to hiring requirements. I am satisfied that USACE did ultimately staff properly to effectively manage the CPAF contract. Unfortunately, much of the staff had no previous knowledge or experience with cost reimbursable contracts, much less a CPAF contract. Many of the employees brought a "Fixed Price" mentality to the job, making the learning curve excruciating."/86

It's clear from this comment that the early understaffing was only part of the problem. The other part was that CPAF contracts were foreign to USACE's corporate culture. Its managers weren't trained to administer this kind of contract. Since its recruiting pool was restricted, MED simply couldn't staff the contract with enough people who knew how to monitor MKSAC. They attempted to do what they'd been trained to do on fixed price jobs - monitor the contract. One USACE manager with experience in cost reimbursable contracts maintained:

"...you don't monitor a cost-plus contract. You run it because, if you don't run it 24 hours a day, it goes completely out of control. You cannot live with the costs and you cannot live with what gets turned out. You must be the manager of that cost-plus contract because there is no way that you can build incentive in there for [the contractor] to put the first team in, to do things cheaply."/87

MKSAC quickly fell out of favor with the Saudis. They pushed MED to let the life/construction support contract expire after its first 3 years (in 1980) and put the same

functions out for competitive FFP bidding. The timing was terrible because the KKMC project was entering its major construction phase and contractor support demands were peaking. MED resisted because it saw more pitfalls in trying to turn over all of MKSAC's equipment, materials and functions to a new contractor without interrupting support than in living with the old contractor's inefficiencies. MED tried to negotiate a fixed price extension with MKSAC but felt the contractor's proposal was outrageous. Ultimately, the Saudis prevailed and MED put the remaining life and construction support requirements into 2 competitive FFP contracts.

Al Batin District planned every detail for the transition between support contractors and managed to complete the turnover with minimal disruption to construction contractors. Its ability to make this transition at a critical stage in the project without throwing the entire effort off schedule must be considered a major factor in its ultimate success.

The Corps of Engineers was considerably more successful in managing its FFP construction contracts. Although some of its 38 contract packages were under \$10 million, 10 were in the range of \$100 to \$270 million and one exceeded \$300 million. This was in line with the MED master plan to create FFP contract packages in the \$100 to \$200 million range. The planners felt that contracts of this size would be extensive enough to interest large international firms without

eliminating smaller but qualified firms from competition. The District prequalified all bidders to ensure that they were capable of performing on the critical contracts. The results supported the planning objectives. By and large, the contractors were well qualified and performed effectively.

Even though the CPAF contract was poorly executed, it allowed mobilization and construction support work to begin before the A/Es completed facility designs. In turn, this bought time for the A/Es to finish designs in sufficient detail to make FFP contracting practical. This enabled MED to use USACE's preferred form of contracting for construction packages. MED's employees were trained and experienced in this form of contracting. The organization had time-tested standing operating procedures for dealing with FFP contractors. MED did an excellent job administering its construction contracts despite being short on construction inspectors. Of course, the FFP contract managers had their share of problems, but few were related to the type of contracting selected.

3.5.2.2 CONTRACT DISPUTES

One of the most difficult facets of contract administration is avoiding and resolving contract claims and disputes. The KKMC project was rife with risks for budget-breaking claims.

Of itself, FFP contracting theoretically provides more claim opportunities than other forms. Since price and

performance time are fixed under FFP contracts, builders facing additional costs or delays beyond their control have no recourse but to claim for an equitable adjustment to the contract against the owner or his representative. The other forms of contracting provide (to varying degrees) routine methods of adjusting price and time without placing the contractor and owner in adversarial positions. Of course, reality doesn't always bear out this theory but it's generally accepted that FFP contracts experience more claims and disputes than other contract forms.

Since it has a long history of FFP contracting experience, USACE knew that the probability of claims and disputes was high for KKMC. Five factors increased the likelihood of claims and disputes:

1. MED had only 4 years to produce and integrate the designs for an entire city. The time constraint guaranteed that some significant design omissions and errors wouldn't surface until the construction stage.
2. MED planned huge commitments of GFE, life support and construction support to its contractors. Any delays or inadequacies in providing these services could have cost and time impacts for the contractors.
3. City utilities and facilities were interdependent. Delays in completing utilities for a critical facility would likely have a domino effect on other contracts.
4. International contractors were unfamiliar with USACE contracting procedures. They could easily misunderstand or misinterpret specifications and special provisions in their contracts.
5. Limited opportunities to perform geotechnical studies of Al Batin before completing project designs increased the likelihood of differing site conditions.

The Owner's attitude toward claims and disputes was also potentially divisive. The Saudis' cultural attitude toward construction contractors was combative and uncompromising. A construction manager noted that the Saudis:

"...don't believe in a contract that affords as much protection to the contractor as it does to the Owner... Their concept of doing business is to twist arms. They just don't understand where a contractor has a right to claim and a right to question."/88

Despite this array of obstacles to amicable relations with its construction contractors, MED completed the KKMC project with a minimum of claims. By 1988, MED closed out all contracts and settled \$120 million in claims and disputes for less than \$40 million. On average, there were no more claims per contract than on a stateside project./89 How did MED avoid the crippling disputes which could easily have plagued KKMC?

The answer to this question appears to be found in a mixture of three strategies:

1. An intensive prequalification effort that generally insured high contractor quality.
2. A pervasive teamwork concept throughout the project reduced the amount of contractor - construction manager antagonism.
3. Adherence to proven USACE techniques of dispute resolution, including review by the Engineer Board of Contract Appeals.

During initial project planning, MED began an intensive contractor prequalification process to insure that all contractors bidding on a contract were capable of performing the work. This was critical for two reasons. First, MED had never contracted with most of the foreign firms bidding on

the KKMC work and lacked institutional knowledge of their capabilities. Second, the Division faced a scheduling catastrophe if it had to terminate an inept contractor on a major construction package. Saudi Arabia lacked the internal construction resources necessary to mobilize management, labor and equipment to replace a terminated contractor on short notice. Therefore, firms winning important contracts had to be well-qualified. Initially, MED Rear prequalified KKMC's construction contractors. However, the Division soon realized that it was more effective for the Al Batin District to prequalify contractors because they ultimately had to work with them and the District also had a better idea of whether contractors were overcommitted to other construction projects in Saudi Arabia./90 A residual benefit of the prequalification process was that high quality contractors approached their contracts professionally and tended to avoid making frivolous claims. They were well-organized, planned effectively and rarely generated their own problems. Thus, the claims these contractors made generally had merit and were negotiable.

The second factor which reduced the claims experience was, in part, an extension of the first. MED fostered a teamwork concept that reduced some of the natural friction generated by FFP contracts. Part of this was the result of selecting excellent contractors. These firms, although profit-driven, took great pride in performing quality work. MED also promoted the historic magnitude of the project to

foster a sense of teamwork between the contractors and construction manager. Although I don't want to overstate the importance of this attitude, it's likely that the contractors perceived MED as a buffer between them and the Owner. MED acted as both a mediator and stakeholder in the project's successful completion. Thus, MED could both enforce its contracts and support its contractors. The dual position that MED held in the project allowed it to create a sense of teamwork with the contractors that the Owner would have had difficulty creating on its own. The sense of teamwork is reflected in two facts: (1) contractors generally ignored small claims (under \$10,000); and (2) contractors generally submitted valid claims. Only the amount of an equitable adjustment was questionable in most cases./91

The third and possibly most significant factor which reduced claims and disputes at KKMC was MED's adherence to USACE dispute resolution procedures. Unlike most construction managers in Saudi Arabia, MED strictly followed US dispute resolution standards rather than Saudi Arabia's, which were based more on religious principles than contract law. This seemed to give contractors confidence that their claims would be dealt with fairly. Also unlike most of its counterparts, MED had full authority under the Engineer Assistance Agreement to negotiate and settle all contractor claims on behalf of the Owner. Although its extensive authority didn't always please the client, contractors felt confident when negotiating with MED that an agreement

wouldn't be arbitrarily dismissed by the Owner later.

Of the total number of change orders and claims handled by KKMC contract administrators (I estimate there were ultimately more than 2000, based on 1983 figures), only approximately 50 were appealed to the Engineer Board of Contract Appeals. Most were settled in wrap-up modifications prior to reaching the Board. Less than 10 of the disputes went to the Board for resolution./92 MED didn't employ the mini-trial concept to settle any disputes, so I can't review its effectiveness. Most of the claims and disputes were from 2 of the 5 likely sources identified at the beginning of this section; differing site conditions and mistakes in delivery of government furnished equipment and materials./93

In summary, MED created a plan for building KKMC which was full of opportunities to generate claims and disputes. However, its plan also minimized the effects of the risks it took by adopting respected dispute resolution methods and decentralizing authority to resolve them. MED and its contractors worked as a team to complete the mammoth project and generally acted in good faith with one another. These factors helped hold down the number of disputes and lead to their complete resolution.

3.5.2.3 MANAGEMENT OF INTERNATIONAL CONTRACTORS

The challenge of building a mega-project at a remote location was compounded by special considerations for managing international contractors. They fall in two general

areas: (1) standards and specifications; and (2) cultural considerations. MED discovered that skills required for international mega-project management include the ability to anticipate and plan for differences in contractor cultures and knowledge.

Some of the foreign contractors simply didn't understand US specifications and measurements and tried not to follow them. One of the Al Batin District Engineers remarked, "There's a propensity among international contractors to build things the way they want to build them without regard to the plans and specifications." /94 He then related a story about a Filipino contractor that built a sewage treatment plant. It disregarded the plans and specifications and attempted to install the contract's electrical system as it would in the Philippines. In turn, this required more Corps supervision and considerable rework to correct.

The South Korean companies dominated the major construction packages at KKMC. They followed plans and specifications to the letter, yet almost totally disregarded safety planning. Finally, Al Batin District's construction representatives began to order work stoppages until the Koreans corrected their safety deficiencies. Once they got the safety message the Koreans did a good job. MED won USACE's safety award in 1985. /95

Another example of the need to plan for international contractors comes from the MKSAC contract. MKSAC's Dutch partner for precast concrete plants designed them to European

standards but had difficulty developing American standards to bid for US materials contracts. This problem slowed down plant construction and start up./96

These stories illustrate some of the peculiarities that MED faced by virtue of managing an international mega-project. MED overcame the difficulties mentioned above. However, some of them could've been avoided altogether if the Division had integrated international contracting factors into its project planning.

A related aspect of planning for international contracting is preparing to accommodate the cultural differences of foreign contractor work forces. The need for this kind of planning became painfully obvious at KKMC when MKSAC's workers began to inhabit their mobilization camp. Under normal FFP procedures, contractors set up their own camps. At KKMC, this was a government provided service. It quickly became apparent that different cultures required different types of facilities and some cultures had to be physically separated. MKSAC had recruited its workforce primarily from Turkey, Thailand and El Salvador. The cultural mix was volatile. Turks and Salvadorans using the same dining facility frequently started fights, apparently based on a Moslem-Catholic rivalry. Ultimately, the workers' camps had to be moved to prevent riots./97

In another instance, worker facilities were shown to be culturally inadequate. According to the District Engineer, MKSAC procured Canadian-made prefabricated dining facilities

that were:

"...too nice to put Turks in...And the kitchens really weren't designed for feeding third-country international folks, Thais and Turks, who used big cooking vessels and big sinks."/98

There were several other incidents that point out the cultural pitfalls of an international workforce. The important point of this discussion from the construction manager's perspective is that some of these cultural differences can be planned for to reduce their disruptive impacts. Since MED provided mobilization camps for the first contingent of its construction contractors it should have planned for some of the cultural impacts. However, it doesn't appear that MED considered these cultural differences during project planning for KKMC.

None of the cultural difficulties that MED experienced while managing its international contractors was disastrous. In retrospect, some were even comical. However, the Division had to address these problems at some point in the project. It could have dealt with them most effectively during the planning stage. Instead, construction managers at Al Batin had to solve cultural problems at a time when they needed to concentrate on construction issues.

3.5.3 LIFE CYCLE PROJECT MANAGEMENT

In June 1988, USACE implemented the Project Management Initiative. It represents an organized effort by the Corps to improve project management in its divisions and districts by adopting policies that systematize the entire process of

project planning, organization, staffing and control. A large part of the USACE effort is a program it calls Life Cycle Project Management. Its goals are to:

1. Improve USACE management performance while considering the concerns and expectations of [its] customers.
2. Increase accountability for scope, quality, cost, budget and schedule.
3. Improve project management continuity./99

This initiative came about as a result of customer dissatisfaction regarding their involvement in project planning and execution and USACE's difficulty in establishing long term project accountability. Was this concept applied to the KKMC project? If not, should it have been? I'll summarize three areas of the project I've already described in the case to determine if MED used a life cycle project management concept on the KKMC project. They are: customer involvement in the design and construction process; staffing for continuity and accountability; and establishing systems for continuity.

As I mentioned in Section 3.3.2.1, the customer wasn't deeply involved in establishing some of the basic design criteria for the city. As a result, MED designed KKMC to be a pedestrian city (it planned only 7 parking spaces per 10 houses) but later discovered that modern Saudis value their automobiles. KKMC lacked adequate parking space./100 In addition, the houses were too small to suit Saudi tastes and had to be expanded by an average of two rooms apiece. The change's impacts carried over into the electrical

distribution, water and cooling system designs./101 As construction began, Saudi participation increased. MED created a Saudi Engineer training program under the Engineer Assistance Agreement (EAA) to prepare its MODA counterparts to perform their own construction contracting and engineering management. Saudis also took a larger role in management at KKMC once construction began. Although they infringed on MED's authority as defined by the EAA, the Saudis gained a voice in determining the project's direction that they lacked during the planning stage. Both MED and MODA were responsible for the lack of early customer involvement in the project. MED didn't actively seek Saudi participation and MODA was incapable of visualizing what it ultimately wanted. Still, it's clear that institutionalized customer participation from the earliest stages is an essential part of the Life Cycle Project Management (LCPM) concept. It could have been applied more effectively at KKMC.

The second tenet of LCPM is staffing for continuity and accountability. MED did this reasonably well despite its short term (2-year) contracts for Saudi Arabian work. There was a relatively high degree of continuity in the Division Rear office in Virginia. Since the Rear office was responsible for project development, design and programming, its continuity helped keep the project on course. Also, many employees working in the Rear eventually transferred to offices in Saudi Arabia and vice versa. Thus, although there was high turnover in Saudi Arabia, much of the project

expertise stayed within the MED organization and contributed to KKMC in different capacities. One Al Batin District Engineer noted the importance of continuity as the project matured:

"I think it's important to draw down the same way the organization was built up, leaving the high grades in position until literally the last man leaves there. There are reasons for that, a little different than on the buildup, but just to retain the expertise as an organization draws down."/102

However, MED lacked continuity in some of its key positions, particularly in those held by military officers. Short military tours guaranteed that the KKMC Project Manager (Al Batin District Engineer) would change at least every other year. The Engineer Studies Center noted in 1984 that MED, "did not have project managers responsible for projects from start to finish and involved in all aspects of the operation."/103 The lack of continuity at the top of the organization muddled the accountability trail as the project progressed. In the final analysis, MED's personnel continuity and accountability procedures during the KKMC project were adequate but probably wouldn't fulfill LCPM's requirements.

Since MED couldn't assure continuity through its personnel policies, the Division developed systems to provide procedural continuity on the KKMC project. The Chief, Construction Division for the Al Batin District explained that the District developed a systems concept to support the construction program:

"By systems concept, I mean developing systems that we

could follow - a piece of paper right on through from the bottom of the organization to the top. And be able to establish strong SOPs [standing operating procedures] so that no matter how big the organization grew, everybody would know how to operate and be able to fall in very easily."/104

Where appropriate, the Project Manager used time-proven USACE procedures. Where he found them lacking, he developed his own procedures and institutionalized them within the District. Al Batin District also made use of USACE's Training Division in Huntsville by arranging for it to teach classes at Riyadh on estimating, negotiating, inspection, safety and quality management. MED also held seminars for resident engineers and contracting officer representatives. It created a Society of American Military Engineers post at Al Batin to provide a forum for exchanging ideas regarding construction in the desert. MED encouraged its contractors to join and invited them to make presentations. In this way, MED diffused knowledge and standardized its systems in a way that promoted continuity within the organization. The systems and procedures developed during this time lasted through the entire Saudi construction program. In some cases, they were adopted by stateside districts. Therefore, I feel that MED's systems concepts provided continuity in areas that couldn't be guaranteed by its customer involvement and personnel policies.

Thus, although MED didn't follow a Life Cycle Project Management concept to the degree that was recently mandated by USACE, it exhibited elements of the philosophy. MED's failure to involve the customer in the project's early stages

and its inability to stabilize KKMC's key project managers had a negative impact on the Division's performance. By the same token, MED's ability to retain and reassign many of its top managers within the Division and the management systems it developed improved project continuity. In my opinion, this validates the LCPM concept. Its full implementation would have had a positive impact on the KKMC mega-project.

3.6 CASE SUMMARY

Over a 12 year period, the US Army Corps of Engineers Middle East Division performed the largest and most challenging single military construction project in USACE history. It entered an area with a harsh climate and no infrastructure, labor or manufacturing base and built a \$6 billion city for 50,000 people. The Division completed the project within its schedule and budget constraints and turned over the fully functioning city to the Saudi Arabian Ministry of Defense and Aviation. MED also trained its customer to be self-sufficient in construction management. The Division accomplished its objectives in Saudi Arabia.

The purpose of this case study has been to determine the effectiveness of MED's mega-project planning, organization, staffing and control efforts. To that effect, I've reached several conclusions. They're stated below under the four applicable management areas and fall within the categories of strengths and weaknesses.

PLANNING

Strengths

1. Excellent project master plan detailed design and support considerations.
2. Excellent quality of design work.
3. Contractors responded positively to MED's commitment to provide government furnished equipment, materials and services by lowering risk contingencies in their bids.
4. Validated the USACE concept of "centralized planning" and "decentralized control".

Weaknesses

1. Didn't adequately determine user design requirements and cultural considerations.
2. Didn't adequately coordinate design planning with construction planning.
3. Didn't perform contingency planning to accommodate program budget and schedule changes. Based all project planning on a 6-year construction program.
4. Didn't define a GFE program manager. Segmented authority and responsibility for the program.

ORGANIZATION

Strengths

1. MED Rear organization facilitated management of US-based architect/engineers.
2. Functional area control of the project during the design phase was appropriate given the scope of the design effort.
3. Creation of a district organization at Al Batin provided the on-site functional expertise required by the Project Manager during the construction phase.
4. Al Batin District organized its Resident Offices under the Chief, Construction Division's direct control. This arrangement worked well though not normal USACE procedure.

Weaknesses

1. Construction Division's complete geographical separation from Engineering Division impeded timely resolution of design-constructability issues.
2. The Division Forward's office and the District office were located in the same complex (Riyadh) at the beginning and end of the project. This resulted in a duplication of staffs and functions.
3. The Engineering Division liaison element which was added to the District office during the construction phase had no authority to resolve constructibility and change issues.
4. Office of the Chief of Engineers usurped the Project Manager's authority early in the MKSAC contract. This temporarily reduced his effectiveness when dealing with the contractor. It violated the USACE concept of "decentralized project execution."

STAFFING

Strengths

1. Excellent pay and benefits structure attracted a high quality workforce.
2. Effectively used Management Assistance employees from MKSAC, temporary duty personnel from other USACE districts, and Title II consultants to cover shortages of its own personnel.
3. Managed a successful employee outplacement program as the project's staff downsized.

Weaknesses

1. Short military tour lengths insured a high turnover rate for key project managers.
2. High percentage of accompanied tours drove up supervision and administration costs.
3. Understaffed the MKSAC contract with contract administrators. MED couldn't keep up with the contractor's activities.

CONTROL

Strengths

1. Established an effective in-house configuration management computer system in MED Rear to process data and control the schedule through the end of the design phase.
2. Al Batin District created a master integrated network which effectively projected construction support requirements throughout the construction phase.
3. Al Batin District effectively managed its FFP construction contracts.
4. The intensive construction contractor prequalification process generally insured that good international contractors won contracts at KKMC.
5. Al Batin District did an excellent job during its transition from CPAF to FFP life/construction support contracts. It prevented the diminution of services to construction contractors during the transition period.
6. Avoided excessive claims and disputes by promoting a teamwork concept and by following standard USACE dispute resolution procedures.
7. Successfully applied some concepts which now comprise Life Cycle Project Management in USACE. However, it didn't apply some of the concepts very well.

Weaknesses

1. Failed to establish an effective cost/schedule

control schedule for the life/construction support contract. MED lost control of spending and never completely recovered on the contract.

2. Lacked a single data base that could be used by both forward and rear elements of the Division. As a result, each office created its own schedule control systems and data bases.

3. Didn't validate the usefulness of CPM for project control as currently required under USACE contracts.

4. Didn't accommodate cultural differences in the international workforce when it provided life support services. MED didn't prepare for the different approaches to construction that international contractors take.

The KKMC project was not an unqualified success, but USACE overcame the problem areas I described. It's evident from the summary that USACE made some costly mistakes in the way it approached the mega-project. However, the organization displayed the flexibility needed to manage crises and correct deficiencies before they became critical. It also displayed a willingness to take risks and the skill to make most of them pay off. The problems I described are for educational purposes and should not be allowed to overshadow the ultimate success of the project. The King Khalid Military City project is an excellent example of how an engineering/construction manager combines planning, organization, staffing and control to complete international mega-projects.

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CHAPTER 4 - CASE #2: BECHTEL GROUP AND THE INDUSTRIAL PORT CITY AT JUBAIL

4.1 CASE BACKGROUND

Bechtel Group's \$20 billion development program (by conservative estimates) to create a self-contained industrial port city near the site of the old fishing village of Al-Jubail, Saudi Arabia is huge by any standard. That venerable chronicle of superlatives, The Guinness Book of World Records labelled it "the largest construction project in history." Time magazine gushed, "In all the expansive sweep of civil engineering, from the pyramids of the Nile to the construction of the Panama Canal, nothing so huge, or costly, as Jubail has ever been attempted by anyone."/¹ No matter whether you believe the superlatives that have been heaped on the Jubail operation, there's no disputing its significance to the study of international mega-projects.

This chapter is a case study of the construction management techniques applied at Jubail by Bechtel Group through its subsidiary, Arabian Bechtel Company, Limited (now called Saudi Arabian Bechtel Company). The first part of the chapter provides a background on the Jubail project and its challenges. The remainder of the chapter examines how Bechtel addressed those challenges and determines the effectiveness of its management efforts.

The Jubail project's origins go back at least to 1973 when Stephen Bechtel Sr., then the corporation's CEO, met with Saudi Arabia's King Faisal. The King was concerned that

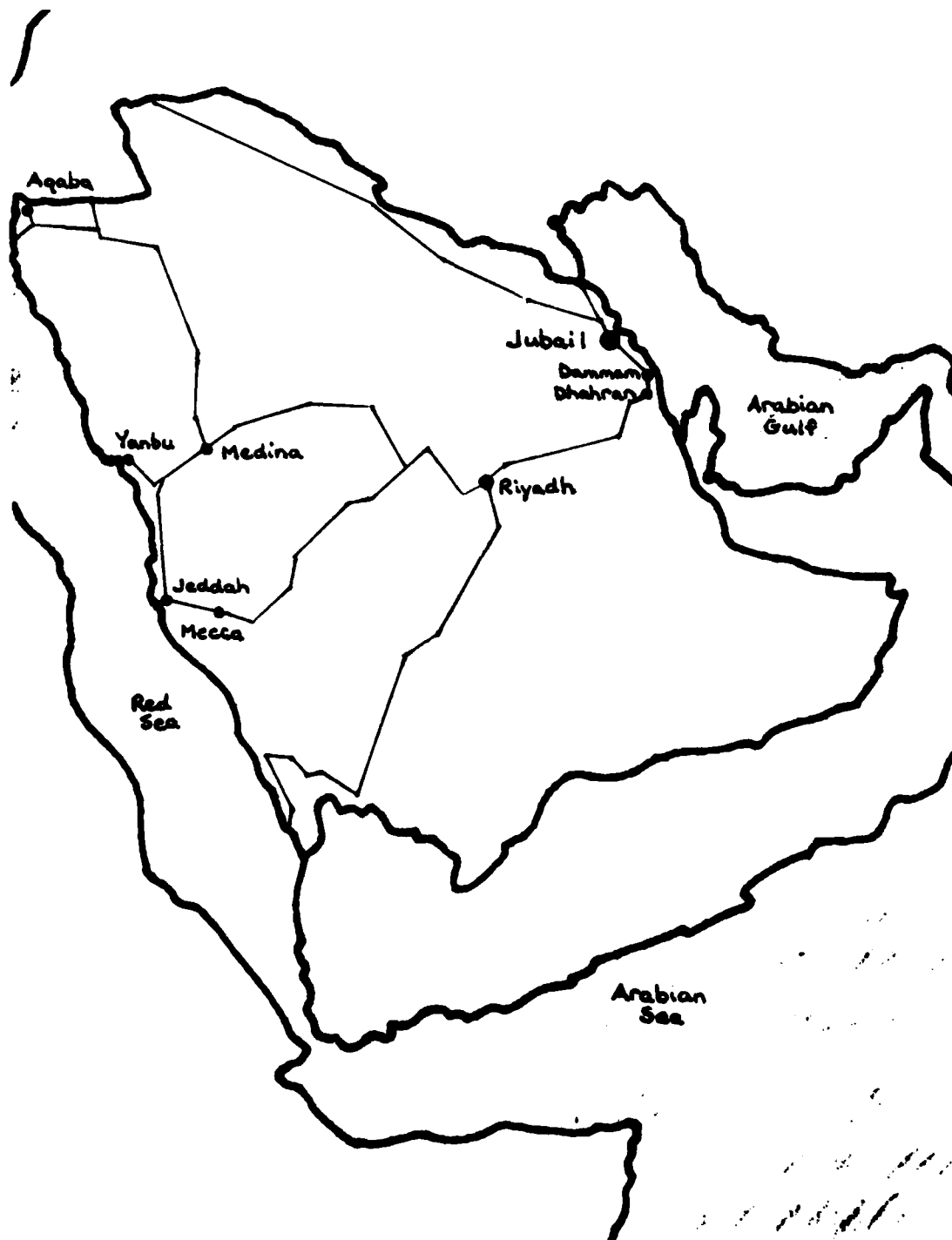
Saudi Arabia squandered much potential wealth by burning off natural gas at its oil fields because there were no cost-efficient uses for the gas. ARAMCO had been working on a long-range gas conservation program since 1956 and had initiated efforts to export liquid natural gas (LNG). However, ARAMCO plans to expand oil production guaranteed that future LNG production would outstrip market demand for the fuel. Some foreign companies, such as Mitsubishi and Shell, had proposed to build industries that used LNG for fuel and methanol and ethanol as feedstocks. However, the effort was fragmented and going nowhere.^{/2} Bechtel initiated an unsolicited study to determine how best to exploit the natural gas resource. It enlisted the help of the Stanford Research Institute (SRI) to evaluate Jubail's development potential.^{/3} After approximately two years of study, Bechtel returned to Saudi Arabia to present a development plan. According to Time:

"Bechtel proposed an audacious solution: assemble a complex of automated petrochemical plants near the oilfields to process and use the wasted gases. The fuel could be used not only to provide raw material for the development of a new petrochemical industry, but also supply the energy to process and manufacture products ranging from plastics and fertilizers to steel and aluminum."^{/4}

The King agreed with Bechtel's concept. After a year of negotiations and further studies, Bechtel produced a master plan for the industrial project at Jubail and was selected to be its construction manager in 1976. Figure 4.1 shows Jubail's location.

The port and industrial city at Jubail became part of a

FIGURE 4.1 MAP OF SAUDI ARABIA SHOWING LOCATION OF JUBAIL/5



larger development program which involved industrialization on both coasts. The Saudi Arabian government planned to expand its industrial base using petrochemicals as both fuel and feedstock. During the Kingdom's second and third five year plans, construction began at Jubail and Yanbu, a smaller sister port city on the Red Sea 200 miles north of Jeddah. The master plan called for development of steel production and rolling mills, as well as ethylene, ethylene glycol and polyethylene plants. In addition, plants at both cities would perform oil refining activities and produce methanol, fertilizer and more ethane-based products. Under the plan, the downstream plants would allow the Kingdom to add value to its crude oil exports and create opportunities to train a Saudi workforce for the future./6

Saudi planners realized that the Kingdom's economy was totally dependent on government crude oil revenues. They determined that the Kingdom's proven oil reserves of 165 billion barrels could be depleted in 65 years. The planners concluded that the Kingdom's future economic success depends on private industrial investment and development. The natural gas development program was the consummation of this ambitious "privatization" concept. The Saudis felt that the industries resulting from the Jubail and Yanbu industrialization projects could, "keep the country's small but rapidly growing population employed and enjoying a rising living standard far into the 21st century."/7

Many Saudi organizations and other construction managers

became involved in the natural gas development program. The Saudi government created an independent, ad-hoc commission called the "Royal Commission for the Development of Jubail and Yanbu" to direct the construction of the ports and cities on the Kingdom's east and west coasts. Its purpose is to provide the infrastructure, land and services to support an industrial complex. This included providing power, water, sewerage, ports, airports and rail networks. To execute those responsibilities, it has more power than other government agencies. The Royal Commission was created to avert bureaucratic delays to development that were common in other government organizations. Initially, the Royal Commission was like a super-municipality, with the additional mandate to build and run schools and hospitals, design and build roads and establish utilities rights of way./8

Other Saudi government organizations, notably Petromin and the Saudi Basic Industries Corporation also became involved in the development program as joint venture partners with multinational corporations. In addition, they created incentives to attract private investment for secondary industries. ARAMCO built a 623-mile liquid natural gas pipeline to connect the two industrial cities and provided oil and gas as industry feedstock. The Saudi Saline Water Conversion Corporation was responsible for creating the fresh water to satisfy Jubail's demand. The Saudi Consolidated Electric Company provided electric power under ARAMCO supervision as part of a regional electrification program.

The US Army Corps of Engineers built a naval base south of Jubail's commercial port.

A number of geographical and ecological factors led to Jubail's selection as the site for the huge industrial port. ARAMCO's lucrative Berri Field is just a few miles offshore. In addition, it is one of the best locations for a port along Saudi Arabia's Persian (Arabian) Gulf coast. There's shelter from Ras Abu Ali, a promontory 10 miles to the north. Also, the Gulf's 100-ft depth contour runs closest to the coast around Jubail.^{/9} The city was built on a 16,000 acre, low-lying area which extends onto the neck of a peninsula north of the industrial complex. Figure 4.2 shows the Jubail's development limits. Figure 4.3 shows the Jubail sub-region and identifies the areas to be developed into the community and industrial sections.

Saudi government agencies formed joint ventures with multinational corporations to build the huge primary industries, then offered a range of significant incentives to Saudi firms willing to put up private money for industrial development. The government offered low-cost loans, tax holidays, extensive oil lifting rights, customs exemptions and freedom to repatriate funds as investment incentives. By 1990, the government's 15 operating primary industrial facilities included an oil refinery, a steel mill, 5 petrochemical complexes, 2 methanol plants, 2 fertilizer plants and factories producing plastics, lubricating oil, sulphur and industrial gases.^{/10} However, private investment

FIGURE 4.2 MAP OF THE EASTERN PROVINCE SHOWING LIMITS OF JUBAIL DEVELOPMENT/11

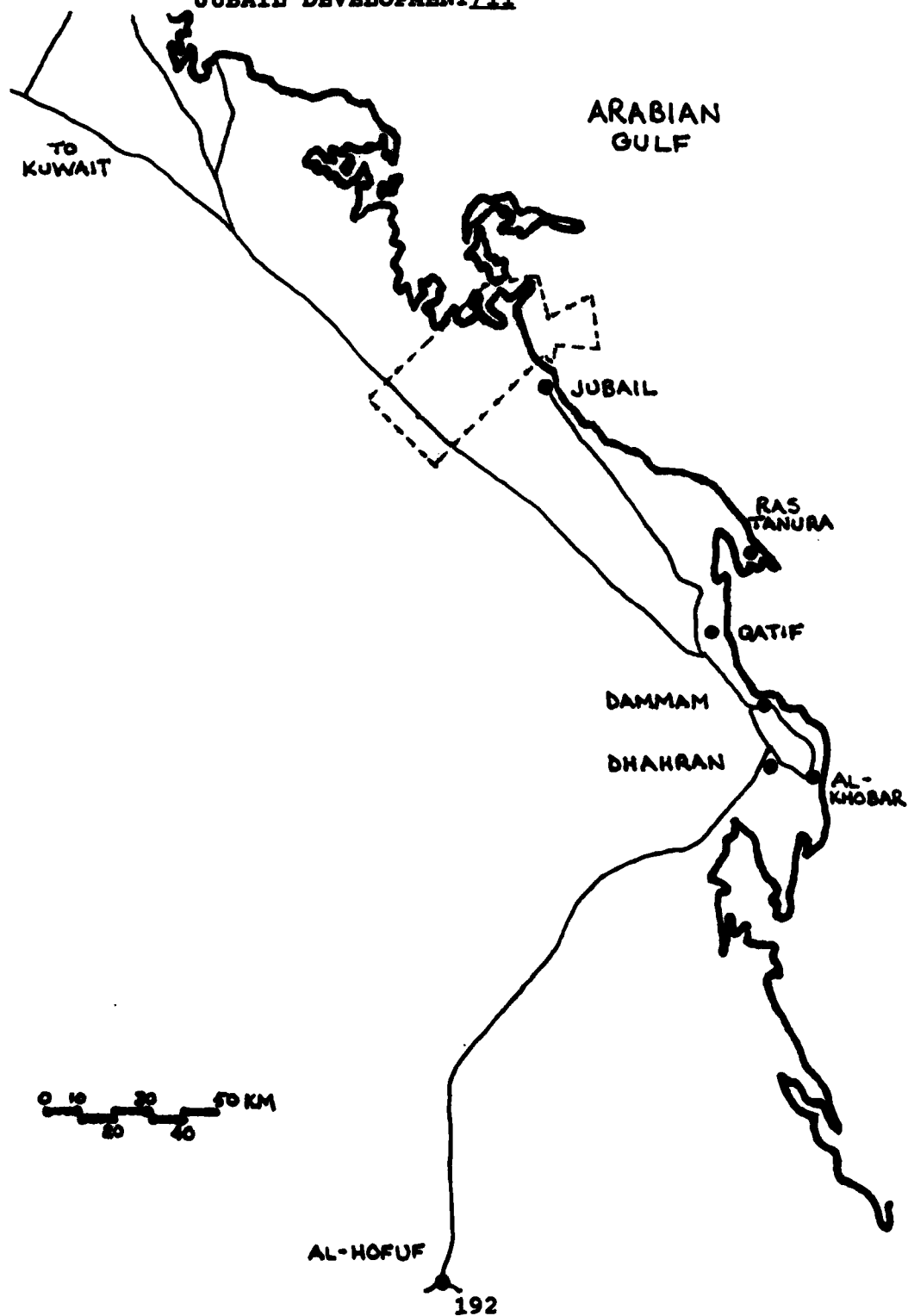
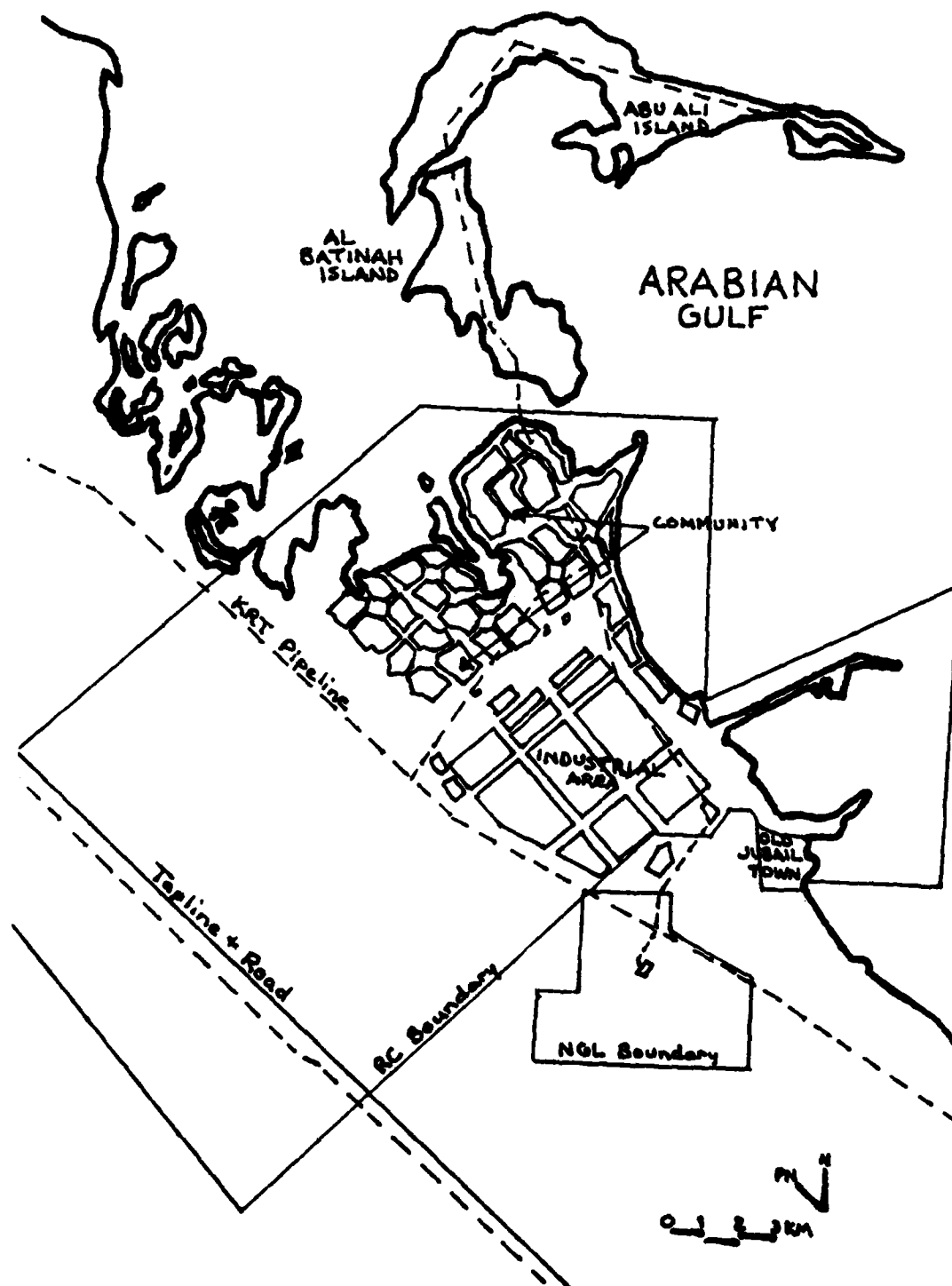


FIGURE 4.3 MAP OF JUBAIL SUB-REGION/12



lagged because of expense and risk of failure. Worldwide production gluts existed in many of the proposed industries, although a predicted pickup in the global economy could stimulate demand. After years of discussions and negotiations, planners had to cancel two thirds of the export industries originally scheduled for Jubail to ensure the viability of the remaining ones./13 As of 1990, the city had only one privately owned petrochemical plant and 64 other support and light manufacturing industries.

Another reason that private industrial development was slower than predicted has been explained by Saudi social scientists. Although the Saudi culture advanced from camels to Cadillacs in little more than a generation, the majority of its people still have strong tribal and regional loyalties. They're reluctant to move away from their traditional home regions to previously undeveloped areas. Since the government has no plans to force worker migration, residents must move voluntarily./14 Some industries have offered potential employees long term home ownership loans to encourage their relocation to Jubail./15 It's not been entirely successful. The city's original target population for 1986 was 170,000, with an ultimate goal of 370,000. In 1987 its actual population was less than 30,000, many of whom were expatriates. In 1990, Jubail had almost 40,000 residents, 77% of whom were Saudi nationals./16

Arabian Bechtel Company, Limited signed a 20-year management support contract with the Royal Commission in 1976

to provide engineering and construction management assistance at Jubail. Bechtel acted as an agent to the owner (the Royal Commission) without the authority to commit funds or enter contracts. In effect, Bechtel was the primary advisor to the owner for engineering and construction matters. Bechtel performed some engineering tasks itself, such as master planning and conceptual design. It wrote requests for proposals and prequalified contractors. Once the Royal Commission awarded a contract, Bechtel managed it through completion as the owner's representative. It also provides assistance in city operations and maintenance.

Award of the Jubail contract in 1976 came at an opportune time for Bechtel. It hadn't been a major presence in Saudi Arabia for nearly a decade and had suffered some major domestic debacles during the same period. The firm was fired from its management contract on the Alaska Pipeline project and experienced contract losses due to the near-collapse of the nuclear power industry. In addition, it faced prosecution by the Justice Department for cooperating with the Arab Boycott of 1973. Although it eventually settled the case out of court, the corporation was severely embarrassed by the episode. It needed a winning project and Jubail was the one. Bechtel projected Jubail to be worth several million dollars in profits to the company every year for the next two decades.^{/17} Bechtel also bid for the job of construction manager on the smaller Yanbu port city but lost to Ralph M. Parsons Company.

From the beginning of the Jubail project, Bechtel and the Royal Commission staffed up and worked closely together. Bechtel trained Saudi engineers for the Royal Commission to take the place of its own staff. As the project advanced, more and more Saudis replaced Bechtel's expatriates. By 1990, the Royal Commission had replaced 60% of Bechtel's staff with Bechtel-trained Saudi engineers. At the same time, 33% of Bechtel's 192 remaining employees were Saudi nationals. According to its Program Manager, "Bechtel has basically accomplished what it came here to do - help the Royal Commission get Jubail up and running successfully and create a self-sufficient Saudi organization."/18

4.2 PROJECT SIZE AND SCOPE

Arabian Bechtel Company, Limited accepted a daunting engineering task in 1976 when it began detailed planning for the Jubail industrial port and city. The official project area covers 355 square miles. The main development is spread out over 100 square miles with a grid of wide boulevards connecting the major sectors. The industrial area is located slightly inland to the south and is divided into sectors. One is for primary petrochemical industries built by government-private joint ventures; another is for secondary industries being developed by private firms; and a third is for light manufacturers that support the primary and secondary industries. At this time, only the secondary sector is still largely undeveloped./19

Bechtel's primary task was to develop the infrastructure needed to support private development of the city. This included the construction of two ports, an airport, cooling water systems, liquid and solid waste handling systems for sanitary and industrial wastes, telecommunications and electrical distribution systems, solid and liquid bulk materials handling systems, road and rail networks. Bechtel also installed generators, wells and small desalination plants as temporary support for contractors until national systems came on line. Bechtel provided fully graded industrial sites with all utilities available at lot boundaries so that, in the words of one employee, "All a company has to do is build its plant and plug it in."/20

Bechtel also had to coordinate its work with that of the government agencies that provide infrastructure on a national scale.

The following summarizes some of the construction challenges:

- A \$1.4 billion, 18-berth port to serve the industrial complex, handling ships up to 60,000 dwt. At the end of a 6-mile long causeway is a 1.8-mile long deepwater tanker terminal large enough to accommodate a 500,000-ton supertanker.
- A \$1.4 billion, 16-berth commercial port south of the industrial port.
- An airport with a 13,000-foot runway capable of receiving any existing aircraft.
- More than 340 million cubic yards of cut and fill was required to raise ground level in the industrial area above flood height. This is enough material to build a road around the equator 9 meters wide by 1 meter deep.
- The development required 200 miles of primary roads, much of it 4-lane.
- A wastewater treatment system designed to treat 40 million gallons per day.
- A cooling water system designed to provide up to 8000 cubic feet per second. Also, a system to re-cool water after use before it's returned to the Persian Gulf. This protects marine life in the discharge area. Its capacity equals the average daily flow of the Rio Grande.
- Three man-made lagoons; two for swimming and one for boating./21

The first primary industry (the steel mill, under the direction of the Saudi Basic Industries Corporation with a West German partner) broke ground in 1980 and came on line in 1982. By then, several other heavy industries had begun construction. Most of Bechtel's infrastructure work was

completed by that time to support industry construction being done by others. Community development continued in tandem because the Royal Commission needed sufficient housing to accommodate workers for the new industries as they were completed.

Although not the subject of this paper, it's worth mentioning some of the huge engineering challenges that Jubail's port designers and constructors faced. Port construction alone involved dredging more than 50 million cubic yards of rock and sand. It enclosed 250,000 acres of water with 12 miles of causeway and breakwaters and reclaimed 1760 acres of land. Contractors dredged 4-mile long, 46 foot deep cuts 100 feet wide to provide shipping channels into both harbors. Dredged material was used to reclaim land for large quays and the 6-mile long causeway.

A 3 to 10 foot layer of cemented calcareous material (called caprock) covered the seabed near Jubail. It has a compressive strength of nearly 9000 pounds per square inch. It took more than a year for the dredging contractors to obtain government blasting permits. In the meantime, the world's largest cutter-suction dredges flailed at the caprock with little effect. Cutter heads often had to be changed as frequently as every 20 minutes. The Dutch port construction contractors designed and built 2 rock breaker barges containing 16 hammers apiece to break through the caprock. Ultimately, the Saudis issued blasting permits and dredging progress improved.

The commercial harbor has 2.5 miles of 56 foot high quay walls made up of precast cellular concrete blocks on a limestone rock foundation. This lies in a trench lined with a synthetic fiber stabilization cloth. Builders combined precast concrete pieces weighing 7 to 15 tons with 2 to 5 ton limestone boulders to form the seaward side of the breakwaters.

The 1.8 mile long deep sea tanker terminal was the most challenging engineering and construction task in the port project. After it investigated deep friction piles, the design consultant (Sir William Halcrow and Partners, London) decided to drill belled piles into a loadbearing mudstone bank to reduce the average pile length by 30 feet. Steel templates with box beams went on top of the piles and 200-ton precast concrete road sections measuring 65 by 35 feet topped the structure. The contractor (Hyundai, Seoul) had to bring in a 1600-ton floating derrick and a 400-ton model to speed the operation./22

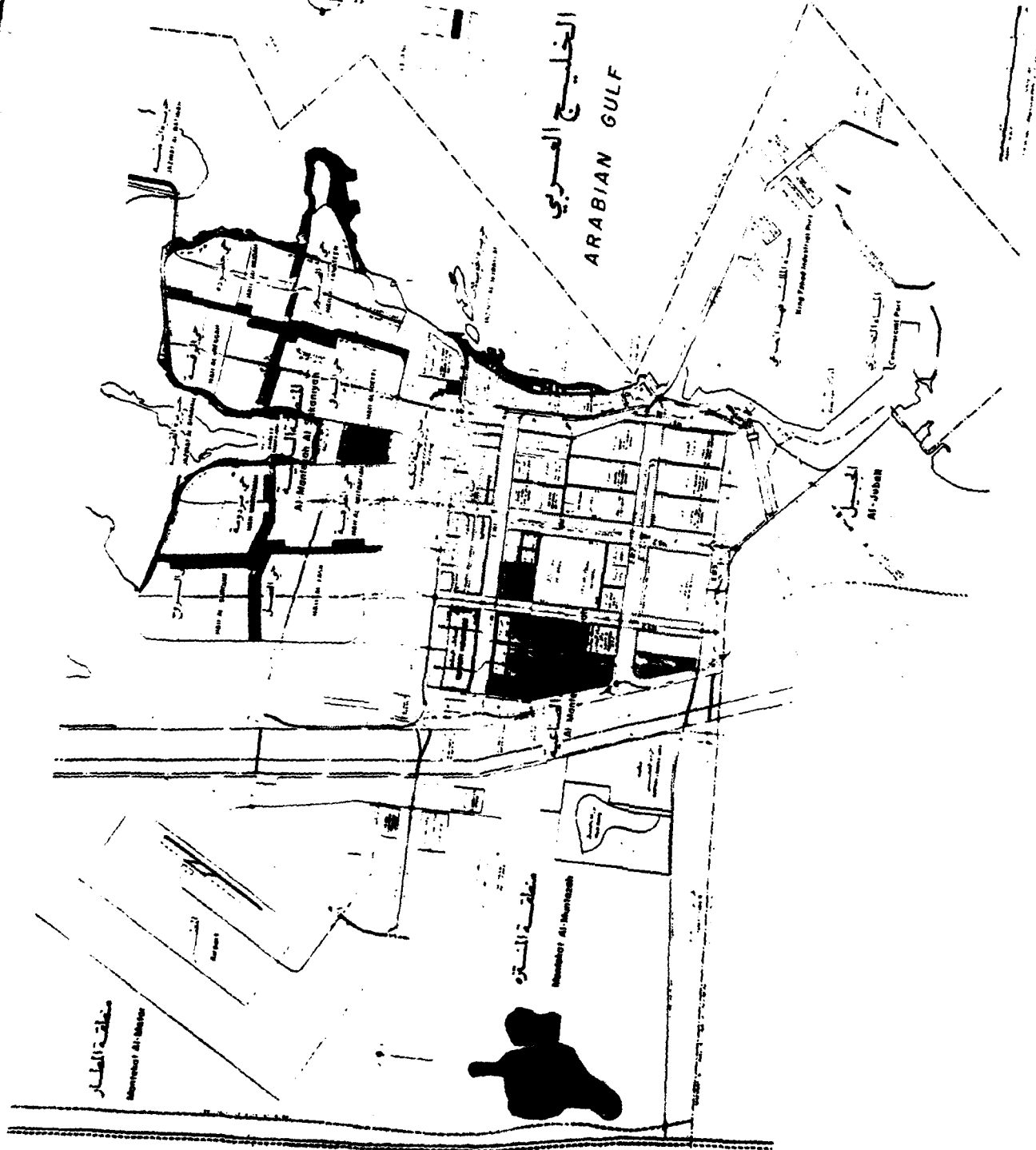
Some additional statistics provide examples of the Jubail project's total magnitude:

- The project required approximately 150 design contracts, 450 construction contracts and 200 service contracts through 1990.
- Bechtel's management force in Saudi Arabia peaked at 1831 workers in 1983.
- The contract labor force eventually came close to 35,000 people.
- Basic program length is 20 years. Most construction was completed from 1977-1985. However, some construction continues today and will continue for the foreseeable future./23

In recent years, Bechtel's role in the Jubail project has evolved from that of construction manager to one of city manager. Construction has tailed off since 1984. The Saudi president of the new municipality described the necessary transition: "Until fairly recently, everyone thought of Jubail as a huge construction job. Now people realize that Jubail is really a modest, but growing city." /24 Figure 4.4 shows the developed Jubail program site.

As planned, the Royal Commission has assumed responsibilities previously performed by Bechtel. Bechtel now assists in city management, operation and maintenance, as well as supervising ongoing infrastructure development and closing out construction contracts. Its management force has scaled down from a high of 1831 in 1983 to fewer than 200 today. By 1996, Bechtel will finally have worked itself out of the job.

FIGURE 4.4 JUBAIL PROGRAM SITE PLAN/25



4.3 PROJECT PLANNING

Although Bechtel had a long history of mega-project accomplishments and considerable experience in Saudi Arabia, it had never built an entire city from scratch before in an area that totally lacked an infrastructure. It faced severe time pressures imposed by the client to match the Royal Commission's industrial development plan. It faced additional planning challenges imposed by a country in which, "The logic of planning was often defeated by [Saudi Arabia's] logic of politics and religion."/26 Saudi Arabian Bechtel Company had to produce a detailed, workable plan to construct the city quickly. This section details and critiques the company's planning efforts.

4.3.1 PLANNING OBJECTIVES

According to Jubail's Program Manager, the overriding consideration that drove and focused project planning was the need to develop the industrial site and community site simultaneously and on a compressed schedule./27 This requirement emanated from the Royal Commission's desire to begin producing commodities at Jubail as soon as possible. Bechtel inherited a timetable that required the first petrochemical plant to be on line by 1982, less than five years from the date of groundbreaking.

The key to project planning, according to one of Bechtel's Program Managers, is, "To know ahead of time, in sufficient detail, what you are trying to do."/28 Bechtel

established three strategies for Jubail's planning which, if met, would enable the organization to meet its planning objective:

1. Break down the project into manageable parts.
2. Conduct planning at contract level.
3. Minimize on-site fabrication./29

The strategies sound simple and, indeed, they're intended to be. Bechtel's planners understood that, at a glance, the project's size and scope was so big it was mind boggling. If Bechtel tried to integrate the entire project plan from the start, it risked getting caught up in its complexity and ultimately going nowhere. This problem plagued the program during its first year. Instead of breaking the program down into manageable parts and producing the optimal design to deliver a functional city by 1982, Bechtel's first Program Manager designed for total program requirements. The company fell behind by attempting to design and contract to build infrastructure for the entire 370,000-person city even though decades would pass before it could be fully utilized. It lost control of the schedule because it couldn't design the city fast enough to begin construction.

When a new Program Manager took charge, Bechtel decided to break the project's conceptual design down into its smallest elements and proceed with an incremental city design./30 Instead of completing all of the infrastructure at once, Bechtel would build the city in phases to match industry requirements. Once the project had been dissected

in this way, planners could recognize the challenges involved in small chunks of the work and create a plan for phased design. The Engineering Department Chief could then match small project scopes to his staff's expertise and assign manageable design responsibilities. Bechtel divided the project by geographical area (industrial, commercial and residential areas) and by systems (power and telecommunications, water and waste, roads, airports, railways, residential buildings, commercial buildings, etc.)./31

This discussion leads to the second strategy-Conduct planning at contract level. Once Bechtel established what the pieces of the Jubail puzzle were, it decentralized planning by assigning the pieces to those who were responsible for the individual parts. Essentially, Bechtel conducted project planning at the individual contract level. After the design parameters had been established at the contract level, Bechtel reassembled the plans to get a picture of the entire program. It then integrated the individual plans to determine where conflicts existed that would affect the program. Where conflicts became apparent, the contract-level planners developed alternative approaches to avoid schedule impacts. Again, Bechtel integrated the proposed solutions into its program plan and studied their feasibility. When necessary, this process continued in iterations until Bechtel solved the problems. The decentralized nature of this exercise allowed a large number

of planners and managers to become involved in the project and help put it together. This arrangement was not merely nice to have, it was a requirement to keep Bechtel from being overwhelmed by the sheer magnitude of the task.

The other primary planning strategy was to minimize the amount of construction performed on site. This gave Bechtel several advantages. First and most important, it saved time because its suppliers preassembled as many components as possible at the factory and its architects designed a modular city. Bechtel designed a special berth at the new port to accommodate some the oversized equipment and building modules that were shipped from foreign factories. The Module Transfer Point could accept pieces weighing up to 2000-tons and with dimensions of 45-meters H x 30-meters W x 40-meters L. Bechtel had to integrate this design with the remainder of the infrastructure to insure that its roads and bridges made a sufficient module path to the industrial area. A 1982 review described Jubail as:

"...a gigantic expanse of clip-together factories and buildings. The 205-bed Al Huwaylat Hospital, provided by the H.B. Zachry Co. of San Antonio, is arriving at the site virtually in kit form and being assembled room by room, each module having been delivered complete, down to the toilet paper holders in the bathrooms. Even the hospital's prayer room, which has mosque carpets and lighting directed toward Mecca, was built in Alabama and transported overseas."/32

Another advantage of the plan for preassembled/modular building components was that it reduced construction costs. Preassembly in a factory setting is more efficient than on-site construction. This advantage was even more evident when

applied to Saudi Arabia because virtually all work was more expensive to perform inside the country than outside. Also, the preassembly/modular concept bought time for Bechtel's civil contractors to prepare the infrastructure Jubail needed to support a massive influx of construction workers, equipment and material.

The final advantage offered by preassembly was that it improved the opportunity for contractor quality control. Manufacturers were better able to control the conditions surrounding production and assembly than construction contractors could. Also, specialized supervisory and testing capabilities existed at the factory that didn't on site. Of course, the large amount of off-site production made Bechtel's quality assurance task more difficult. The firm simply couldn't place quality assurance personnel in each manufacturing plant to monitor production operations. Thus, it risked lengthy project delays if critical preassembled or modular items arrived that failed to meet specifications. Also, it was more difficult to control and force adjustments to manufacturers that had problems meeting the schedule when they were working in another country.

The three planning strategies described above led to another planning decision that Bechtel made to support the them. It placed great emphasis on construction contract sequencing. Bechtel's goal was to identify when each part of the construction program was needed and arrange the parts in the proper sequence to avoid delays. It accomplished this

by creating two kinds of networks. The first was a "physical" network, which identified design/construction interface nodes. Take, for example, the highway design. What utilities had to pass under or over it? Where would the crossings be located? How could the drawings be coordinated between separate projects at the interface point? What group of planners would be responsible for controlling the interface? The second was a "time/budget" network. Using the same highway example; which contracts must be awarded first to avoid tearout and rework? How much detail must be set out in contracts so that builders know exactly where their responsibilities end and someone else's begins? Bechtel managed the "physical" and "time/budget" networks independently but they were interdependent from the total program perspective./33

The Program Manager resolved interface issues identified during the networking process by bringing together his engineering, contract procurement and construction functions and managers of the affected projects to work out a solution. This entire process ties back into the objective of breaking the program into manageable parts that could be visualized. Bechtel had to pick out the key elements of the smaller contracts and sequence them so that they fit properly into the big picture. Bechtel's strict adherence to these planning objectives was a major source of its success at Jubail.

4.3.2 INFRASTRUCTURE DEVELOPMENT

Bechtel faced an extremely tight timetable for completing Jubail's infrastructure. It had to design and build two ports, a road network, an industrial railway, industrial pipelines, install basic utilities and create sewage treatment plants for the industrial and residential sections in tandem. One of the planning difficulties Bechtel faced was to anticipate contingencies caused by delays in infrastructure projects performed by other agencies. Other government organizations were to provide permanent electric power and desalination plants. The power came on line in time. However, Bechtel had to issue a design-build contract to a Japanese Firm to produce a floating desalination plant for an interim fresh water supply. The Japanese manufactured a 6-story-high barge that began processing 5 million gallons of fresh water per day for Jubail within 12 months of contract award./34

The single largest infrastructure planning contingency was to design and build the \$1.4 billion industrial port in 26 months. The Saudis dropped this project into Bechtel's lap with no notice. The Saudi Arabian Port Authority was originally responsible for designing and constructing the port. However, the Port Authority didn't have the capability to manage the large engineering and construction effort. After several months of foot-dragging, the Royal Commission transferred responsibility for the port's construction to Bechtel. The company didn't have the time to go through the

preferred design and firm fixed price (FFP) contracting procedures, so it planned to accelerate the process. Bechtel performed the port's conceptual design, then negotiated engineering-procurement-construction (EPC) contracts to complete it. This plan saved at least a year over the normal design first, formalized construction contract bidding process. It facilitated the port's completion within the required 26 months./35

Bechtel also planned effectively to avoid over-developing Jubail's infrastructure. It master planned 8 community districts, each of which would provide housing and services for 50,000 people. However, it soon became apparent that the industries would not grow quickly enough to justify developing all of the districts at once. Bechtel's plan provided flexibility in district development, since each was designed to stand alone. The company's plan provided site preparation (clearing, grubbing and fill to rough grade) for 6 districts. It provided complete site development (finish grading and major utility distribution lines) for 3 of them. By 1990, Bechtel has completed community construction in 1 district and part of another. This has provided plenty of permanent housing for the active industries. As important, Bechtel avoided over-developing districts that could not possibly be utilized right now. In addition, the districts that have been developed are recognizable as cities in their own right, since each has all the institutional and residential support facilities of a modern city. Thus, they

are complete entities, instead of appearing to be merely part of an unfinished development./36

4.3.3 PROCUREMENT

One decision that may not have directly supported the planning objectives was the Royal Commission's refusal to allow Bechtel to make advance material purchases and provide them as owner furnished materials. Bechtel wanted to procure and provide some important materials and equipment itself. This would have circumvented the delays inherent in completing facility designs and going through the entire bid process before the winning contractor could initiate procurement on his own. However, the Royal Commission was completely opposed to this concept because of its inherent risk of causing contractor claims and disputes. It was adamant that construction contractors procure their own materials and equipment.

The Royal Commission compromised on one important point, however. It approved the use of concessionaires to provide many of the common bulk building materials that almost all contractors required. Bechtel wrote concession contracts for many firms to produce and provide aggregates, bulk cement, concrete, reinforcing steel, asphalt, electrical wire and other materials to its construction contractors. Bechtel negotiated unit prices with the concessionaires but didn't pay them directly. Instead, Bechtel required its contractors to buy these materials from firms on the approved list. This

system gave Bechtel three advantages. First, it provided a way to control materials costs through contract negotiations with concessionaires. The concessionaires faced some competition because Bechtel arranged to have more than one supplier for most of the materials. Also, Bechtel controlled some of the bid elements on its construction contracts because it already knew the actual costs of the concession materials that contractors were bidding.

Another advantage of the concessionaire concept was that it provided Bechtel greater oversight of bulk materials quality. Bechtel quality assurance inspectors could periodically inspect the suppliers to ensure they met contract quality standards. The final advantage of the concessionaire system was that Bechtel reduced risk for both the owner and its construction contractors. Contractor risk was lower because the designation of concessionaires guaranteed them a steady supply source that consistently met specifications. The system reduced owner risk because the concessionaires, not the owner, had the responsibility to provide construction contractors adequate amounts of the specified materials. Thus, the concessionaire concept offered many of the advantages of owner provided materials with fewer pitfalls.

Although it didn't start out with this approach, Bechtel also eventually adopted the concessionaire concept for its construction contractor life support planning. After it completed the 41,000-man contractor mobilization camp,

Bechtel planned to provide life support (mess, facilities maintenance, etc.) itself. It soon found itself overmatched by the magnitude of the support effort. Ultimately, Bechtel created concession contracts for the operation of its mobilization camp and competitively bid them. This proved to be a more efficient system in the long run./37

4.3.4 ENVIRONMENTAL CONSIDERATIONS

Environmental concerns drove some of the planning for the Jubail mega-project. The Saudis wanted to create an environmentally adapted state-of-the-art model city. As a result, the Royal Commission directed Bechtel to follow existing US environmental protection standards when it designed Jubail. Saudi environmental policy was as yet undeveloped.

A major issue sprang up immediately. The industrial port site was near some of the best fishing grounds in the Persian Gulf. Shrimp, in particular had been harvested just off-shore for decades. Bechtel determined that water from the seawater cooling system would gain an average of 15 degrees (F) during industrial use before being discharged back into the Gulf. Thus, officials became concerned during conceptual planning that the cooling water would raise the Gulf's temperature several degrees near the old fishing center at Al-Jubail. They predicted that the warmer water would have a devastating impact on the shrimp population. Bechtel had to determine a way to mitigate the outfall's

effects on the coastline.

Its environmental engineering consultants calculated through computer models that they could use the industrial port's long causeway as a cooling manifold for the discharge. They could reduce the outfall water temperature 14 of the 15 degrees it had gained from the industrial process by routing the used water through a pipe running the length of the industrial port's 6-mile causeway. Smaller branch lines would apportion the flow at intervals along the port. The longer outfall run would allow the water more time to cool and branch lines would scatter the discharge water across a wide area. Bechtel accepted the plan and incorporated the idea into the industrial port's conceptual design. After several years of operation, it appears that the mitigation plan works effectively./38

Bechtel also designed state-of-the-art pollution and toxic chemical controls into its industrial area utilities. It used extensive sand stabilization techniques and provided for camel crossings over highways, railways and pipelines to accommodate Bedouin nomads. Bechtel avoided using underground aquifers for fresh-water supply because other parts of the country had experienced severe aquifer depletion by over-using wells. All fresh water at Jubail was provided by desalinating water from the Gulf.

It's evident that Bechtel made an honest planning effort to mitigate environmental impacts at Jubail. However, it didn't face organized opposition to the area's development by

knowledgeable interest groups, as one would expect of an international mega-project in a fragile environment. As a result, Bechtel faced no threat of costly construction halts and court battles when it planned for Jubail's contingencies. Thus, its environmental planning experience at Jubail doesn't illustrate the kinds of management challenges that builders can expect to face in future mega-projects.

4.4 PROJECT ORGANIZATION AND STAFFING

One of Bechtel's Program Managers at Jubail claimed that the program placed greater demands on organizational skill than on engineering expertise./39 Bechtel recovered from an early failure to establish a viable Jubail program organization. Although the current organization no longer resembles the one originally conceived to get it back on track, it's the result of a 14-year evolution rather than a revolution. The size and composition of Bechtel's staff has changed significantly as a result of "Saudiization" and completion of the program's major construction projects. In this section, I examine Bechtel's organization and staffing throughout the project and determine the effectiveness of its selections.

4.4.1 ORGANIZATION TYPE

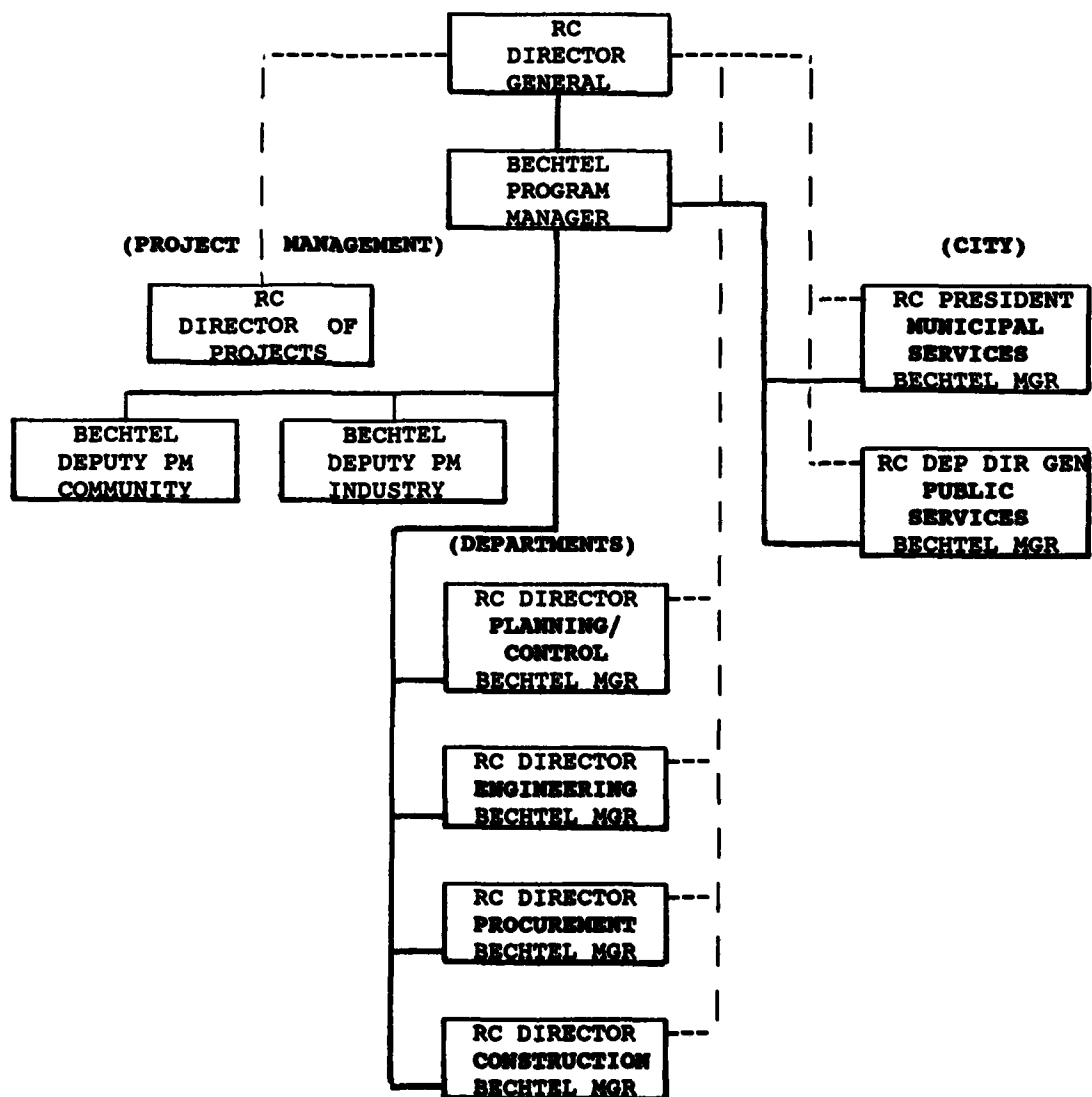
Bechtel removed Jubail's first Program Manager after early projects fell far behind schedule. One of the reasons for the change was that the Program Manager had failed to create an organization that could grow to keep pace with program requirements./40 Engineering and contract procurement lagged and caused the program to fall behind in its first year. The new Program Manager made creating an appropriate organization his top priority. After the change, Bechtel's organization type remained remarkably consistent from the planning through the design and construction phases. The company established a matrix organization with

integrating managers imposed on a functional structure. It has only recently evolved into a flat organization with complete functional management./41

The organization has always had a unique feature because of the Royal Commission's involvement, however. The Saudis superimposed a parallel organization on Bechtel's. The Royal Commission matched every Bechtel functional or project area manager with one of its own. The Royal Commission Director General is the Program Manager. Bechtel's Program Manager heads the management services contract group and reports to the Director General. Bechtel and the Royal Commission totally integrated its workers at lower levels of the operations and functional departments, as well as in the entire city management organization.

In the early years, the Jubail Program's organization had three main components; Project Management, the Departments, and the City. The Royal Commission's managers in these three areas reported to the Director General. The management services contractor's managers reported to Bechtel's Program Manager. Figure 4.5 shows these parallel organizations at the highest levels of the three main components. Note that each Bechtel manager had a Royal Commission counterpart, except for Bechtel's Deputy Program Managers for the Community and the Industry Construction. The Royal Commission chose to assign one man as Director of Projects instead of assigning equivalent managers to each of the two major construction areas.

FIGURE 4.5 JUBAIL PROGRAM ORGANIZATION/42



NOTE: Solid line is Bechtel's chain of command and control. Dotted line is the Royal Commission's chain.

Although the Royal Commission maintained this parallel organization throughout its lower tiers, I'll delete its organization from further figures and discussion to avoid confusing the subject of this study. Also, I'll not discuss Bechtel's involvement in the "City" component of the program organization since, aside from its advisory responsibilities at the highest level (the Municipal and Public Services Managers), Bechtel personnel were totally integrated with the Royal Commission in this area. The City component was, in effect, the client for the Construction Management component.

At the top of the Bechtel organization for Jubail was an autonomous Program Manager. The Planning/Control, Engineering, Procurement and Construction Department Managers were staff leaders who reported directly to the Program Manager and coordinated the entire effort. These departments were staffed with functional area experts who assisted the line managers and coordinated with the A/Es, clients, the other departments and project managers on interfacing issues. The Planning/Control Department tracked and analyzed construction progress, manpower, cash flow and work forecasting. The Procurement Department prequalified contractors and evaluated bids. It also took part in negotiations to clarify bids.

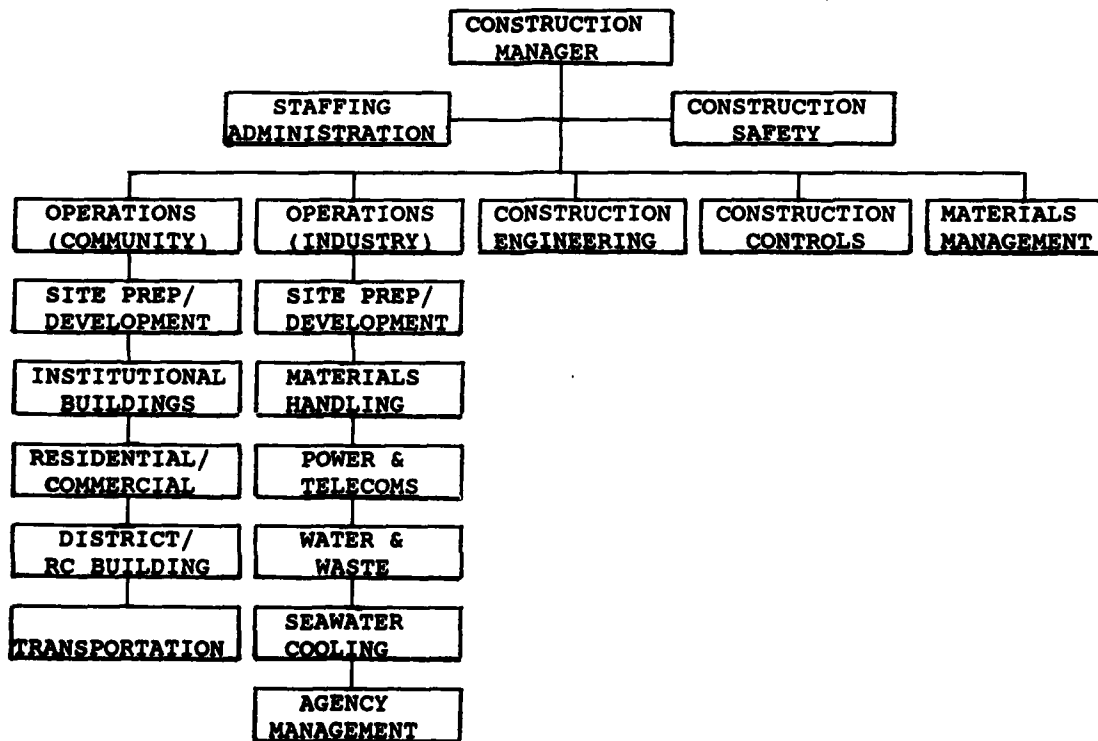
The Engineering Department divided the program into 10 functional groups that matched the program's construction systems - such as materials handling, water supply and wastewater, and power and communications - and placed an

engineer in charge of each. The Project Engineers coordinated the designs of all A/Es in their functional areas. They placed Bechtel representatives in each A/E's office to assist in coordinating the design. The Project Engineers also coordinated their jobs and reports with Project Managers from the two Project Management groups that I'll describe below.⁴³ The Engineering Department reviewed contract packages for constructability, developed standard specifications, drawing details and procedures.

Figure 4.6 shows the Construction Department's organization during this period. Like the other departments, it provided both expert pooled staff assistance across the projects and dedicated staff for the separate projects in a matrix form. Unlike the other departments, it also permanently assigned staff members to work on Construction Project Teams in line relationships, thus strengthening the matrix. The Construction Department also had a small team that coordinated with industries and other government agencies for product piping right-of-ways, constructability and interface reviews and agency construction progress monitoring.

The Deputy Program Managers for Community and Industry Project Management had operational responsibility for construction of all infrastructure and Bechtel-managed facilities. They assigned Project Managers to each of the 10 "systems" being constructed in the two geographical areas. The systems which fell under the Project Management Groups

FIGURE 4.6 BECHTEL CONSTRUCTION DEPARTMENT ORGANIZATION/44



are identified below:

1. Community Group

- Site Development
- Institutional Buildings
- Community & Religious Buildings
- Residential & Commercial Buildings
- Parks & Health Facilities

2. Industry Group

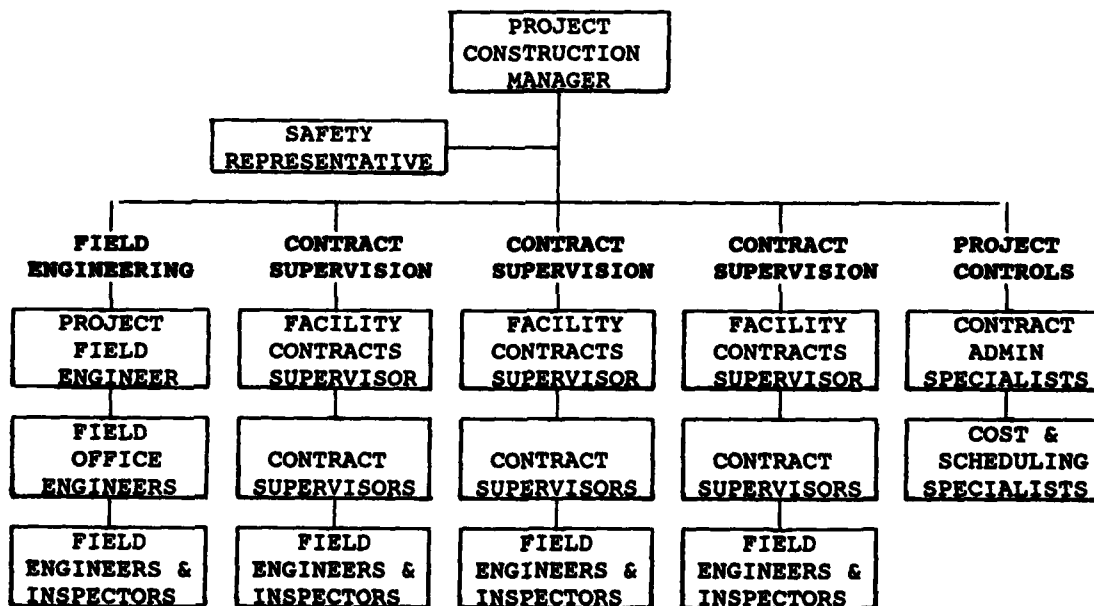
- Site Preparation
- Material Handling
- Power & Telecommunications
- Water & Waste
- Transportation/45

A Project Manager from one of the Project Management groups headed each of the Construction Project Teams. He reported directly to the Deputy Program Manager for either Community or Industry. The teams were divided into sections with both line and staff relationships. Figure 4.7 typifies the organization of a Bechtel Construction Project Team. The line and staff relationships follow:

- Contract Supervision (Line)
- Field Engineering (Pooled support - assigned to line supervision as required)
- Cost and Schedule (Pooled support staff)
- Contract Administration (Pooled support staff)
- Safety (Staff)

The number of sections in a Construction Project Team varied from 3 to 5 depending on the project's extent. A Facility Contracts Supervisor headed each section and was designated "Authorized Representative of the Royal Commission" for contract management. Several contract

FIGURE 4.7 ORGANIZATION OF A BECHTEL CONSTRUCTION PROJECT TEAM/46

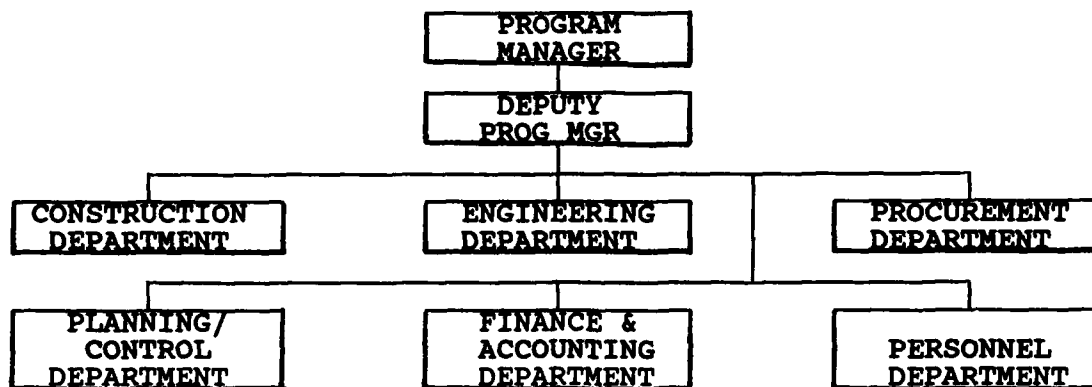


supervisors worked for him, depending on the number of contracts. The Project Field Engineer reported as a staff function to the Project Construction Manager. Field Engineers and Inspectors provided both pooled staff and line support. Cost and Schedule Control specialists provided pooled staff support for work planning input, cost and schedule reviews of contract packages during formulation and monitored and forecasted costs, manpower and progress. Contract Administration specialists provided pooled staff support for documenting contract matters. Finally, Safety specialists were assigned to each Construction Project Team as a staff asset to monitor contractor safety programs.

The matrix organization that Bechtel selected was well suited for its mission. It organized on a functional basis for economy and expertise. However, Bechtel also assigned the Operating Groups' Project Managers enough personnel and gave them adequate access to pooled staff resources to be responsive in Jubail's fast-paced construction environment. This arrangement provided the resources that the Project Managers needed in order to be proactive on their contracts.

As construction progressed and became a smaller part of the program, Bechtel's responsibilities and, hence, its organization has become smaller. It's now flat, with a Program Manager and 6 functional areas. Figure 4.8 shows the current organization, as Saudiization becomes more of a reality and the program settles into the city management phase.

FIGURE 4.8 BECHTEL'S JUBAIL ORGANIZATION - 1990/47



Under the current organization, Bechtel eliminated its Project Managers. Its austerity is dictated by staffing levels imposed by the client. Bechtel is no longer involved in the City Organization and has reduced capabilities in field supervision and planning./48

4.4.2 ASSIGNMENT OF RESPONSIBILITY AND AUTHORITY

Although I don't intend to study construction manager - client relations in this thesis, it's impossible to examine Bechtel's internal authority structure without understanding the Bechtel - Royal Commission contractual relationship. Bechtel has suffered throughout the Jubail Program from being given a considerable amount of responsibility without commensurate authority. Early in the program the Royal Commission's first Director General made it clear who retained authority when he said:

"There is but one Manager of the Jubail Project and that is the Royal Commission. In the beginning Bechtel will do all the work and in the end the Royal Commission, having learned from Bechtel, will do everything."/49

From the beginning, the Royal Commission reserved the authority to sign contracts and pay contractors. However, it has proven reluctant to take control of Jubail's operations. This leaves Bechtel in an awkward position. Although it has always technically been part of the Royal Commission's organization, only recently have the parallel organizational lines of the two groups begun to blend. As the lines merged and the Royal Commission gained more capability, one expects it would also have accepted more responsibility. Instead, it left Bechtel with much of the workload and even more restrictions on its authority. A current Bechtel manager noted:

"In theory, authority and responsibility are compatible. In practice, the Royal Commission has increasingly imposed bureaucratic restraints and taken positions which limit our ability to manage as effectively as we would wish."/50

Bechtel's internal authority structure appears to be more sensible. During the prime construction phase of the program, Bechtel established 6 centers of authority and responsibility. They were:

1. **Program Manager** - Given complete responsibility and authority by Bechtel Group to carry out the program.
2. **Two Deputy Program Managers** - Operational responsibility and authority to complete construction projects in their separate geographical areas.
3. **Department Managers** - Functional managers and influential staff advisors to the Program Manager. Engineering and Construction department managers had the additional responsibility to coordinate all design and construction efforts, respectively.
4. **Project Construction Managers** - Direct operational responsibility to complete high-quality construction

in their project areas on time and within budget. Also responsible for inter-department planning and coordination in their project areas. Had dedicated Construction Project Teams to increase authority.

5. **Project Engineers** - Coordinated the work of all A/Es in their functional areas. Responsible for coordinating with Construction Project Managers on constructability and interface issues.
6. **Facility Contract Supervisors** - Responsible for managing individual construction contracts. They were designated "Authorized Representatives of the Royal Commission" with the authority to direct contractors and authorize payment - within the contract terms and policies established by the Royal Commission.

Bechtel's authority structure complemented its matrix organization. The Jubail Program Manager had complete control of all Bechtel operations groups and functional departments working on the project. However, he decentralized both planning and execution to the project operational level, while maintaining the capability for centralized decision making at the program level. Project Managers' responsibilities in the 2 operational groups (Community and Industry) were usually geographically separated. However, Industrial Group Project Managers were responsible for interfacing in those areas where crossovers occurred. For example, the Transportation Project Manager (from Industry) was responsible to construct major road arteries that ran through the Community Group's area. The Community Group built secondary road networks in its area. Likewise, the Power and Telecommunications Project Manager (Industry) was responsible for providing the major power distribution system into the Community. The Community picked

up from there to provide the subnets. In any case, Bechtel made it clear who had responsibility and authority for coordinating interfaces between the 2 operational groups managing the construction.

The Program Manager expected his organization to settle conflicts at the lowest level. When internal differences occurred between line and staff members of Construction Project Teams, Project Managers attempted to settle them with their functional counterparts. Failing that, the appropriate Deputy Program Manager for Operations worked out the differences with the Department Managers. Only the most serious matters that defied lower-level resolution went before the Program Manager.

Bechtel also created a system of checks and balances within its organization by establishing separate reporting chains and dual reports for the operational groups and functional departments./51 The Program Manager compared the periodic reports to determine if everyone on his staff had the same perception of planning, progress and problems. Discrepancies became the subject of coordination meetings that enforced the teamwork concept and ensured the right problems were addressed.

Bechtel delegated authority to the lowest possible level. The Program Manager gave Facility Contract Supervisors the maximum authority allowed by the Royal Commission to carry out their responsibilities on individual construction contracts. The organization also matched the

level of authority with responsibility for its functional staff members. They had adequate resources and authority to carry out their planning, coordination and technical assistance functions. Bechtel delineated lines of authority and responsibility well enough to avoid major confusion in program planning and development. Its organization also successfully avoided a systematic duplication of staff and effort.

4.4.3 STAFF LOCATIONS AND EFFECTIVENESS

The decision Bechtel made to locate its management staff in Saudi Arabia was one of the strong points of its management efforts. Although Bechtel performed some contracting and personnel activities early in the program from its offices in San Francisco and London, the Royal Commission wanted Bechtel's entire staff to be located in Saudi Arabia. Despite the significant cost implications of recruiting, moving and maintaining a workforce in Saudi Arabia, Bechtel complied and had excellent results.

With virtually no exceptions, Bechtel created an organization in Saudi Arabia at Jubail under the Program Manager's direction. Although personnel functions continued to be performed by the Home Office through the peak construction years, all of the other functions were located at Jubail with the Program Manager. This was a significant advantage from a command and control point of view. Bechtel staffed the organization to be self-sufficient. It imbued

the functional staff at Jubail with the appropriate expertise to enable them to address even the most technical matters internally. In addition, the staffs at Jubail weren't involved in any other Saudi Arabian programs, so there were no other projects competing for their attention.

The close proximity of staff and project managers facilitated planning, scheduling, design and construction interface coordination efforts. It also reduced the potential for duplicating staff and work and it simplified the procedures for imposing corrective measures when they were needed.

Since almost all of the detailed design work for Jubail was performed off-site by architect/engineers around the world, Bechtel assigned Resident Engineers to the headquarters office of each firm to help coordinate their efforts. The functional Project Engineers and the Resident Engineers worked together as equals, although design control remained with the Project Engineers./52 Some of the A/Es weren't used to this level of scrutiny by engineers from a competing firm and felt uncomfortable with the presence of Resident Engineers in their offices. It was clearly not a normal procedure and at least one of the primary architects felt the arrangement hindered, rather than facilitated progress./53 However, Bechtel feels that the Resident Engineers helped identify and address possible interface problems during the design phase, when they could correct them inexpensively.

4.4.4 PERSONNEL DECISIONS AND EFFECT ON STAFFING

Less than 2 years after it won the management contract, Bechtel had assembled a Jubail workforce of 600. During the peak work placement year, 1983, its workforce peaked at 1831. Bechtel's current force is less than 200 since the Royal Commission's own staff has increased significantly. In all, more than 5000 Bechtel employees have participated in the project during its 14-year history. How did Bechtel's personnel policies enable it to staff up so quickly in such an austere environment, then cut down sensibly when the time came? I'll answer that question in this section.

Bechtel had a distinct personnel advantage going into the Jubail Program. The Group's myriad of operating companies and wholly-owned subsidiaries had experience in virtually all of Jubail's engineering functional areas. Its organizational base was already in the Kingdom in the form of Arabian Bechtel Company, Limited. Bechtel Petroleum, Chemical and Industrial Company and Becon Construction Company had personnel with considerable experience in petrochemical and industrial plant design and construction. Bechtel Civil Company had experts in airport, roadway, railway and port construction. Bechtel Telecom, Incorporated was full of communications systems experts. There are too many examples of in-house expertise to mention all of them here. In summary, the company generally had enough capability to recruit key management and engineering

positions from internal resources. Also, Bechtel Group was able to loan the services of ultra-specialists to Jubail for short periods of time when required.

Still, Bechtel couldn't afford to decimate its existing companies to fully staff the Jubail project. Also, it had to recruit some specialties that Bechtel didn't normally staff. For example, Bechtel had to recruit health and community service workers, security experts and education administrators to fulfill its city management mission. Bechtel split personnel recruitment goals between three separate geographical areas and job groupings. The majority of the professional staff was American and came from Bechtel business lines. This accounted for approximately one-third of the peak manning level. Another one-third of professional staff and middle management came from international sources - primarily British, Canadian and Australian. The remaining third, consisting of secretarial, clerical and manual workers, was Filipino.⁵⁴ About half of all employees had no prior experience with Bechtel. The company also sought Saudi nationals to fill positions and had more success locating qualified ones as the program progressed. Many of its Royal Commission engineer trainees later joined Bechtel because of the company's more attractive pay and benefits.

Bechtel created an impressive contractual package of pay and benefits to attract the needed workers to Jubail. Some of its features were:

- Pay. Offered an approximate 40% premium over standard wages for a 60-hour, 5-day work week. Later

in the program, this became a 54-hour week.

- **Accompanied Tours.** Authorization for family accompaniment depended on the worker's level and number of years in the organization. Generally, young professionals with 7-9 years in the company and older people with less experience were qualified to bring their families at Bechtel's expense. This amounted to about 20% of the total staff.
- **Vacations.** All employees were allowed one paid home leave per year and an extra week's leave above the norm. Married staff also received a European R&R.
- **Housing.** All housing was modern, high-quality, furnished, air conditioned, with free utilities (other than telephone)./55

In return for these benefits, workers signed 2-year contracts. Bechtel actively encouraged its employees to extend their tours. Ultimately, the average worker stayed at Jubail for 3 years. While some employees didn't complete their 2-year contracts, many stayed as long as 6 to 8 years.

Even with this great package of pay and benefits and an international job market to select from, it took the Program Manager 7 months of almost full time effort to flesh out his matrix organization. A prime reason was that the job required of its managers both a requisite level of skill and a temperament which would accommodate working with the Royal Commission. After Bechtel located 3 or more qualified applicants for key positions, the Saudis often interviewed them and selected the man that best suited their personality preference./56 The Royal Commission provided sufficient funding to ensure that Bechtel could adequately staff for peak construction.

As Bechtel completed the major construction projects in

the mid-1980s, Royal Commission cost-cutting measures impacted Bechtel's staffing. The company is no longer able to adequately staff its project to fulfill all of its contractual obligations due to staffing and cost limitations imposed by the Royal Commission./57 During the drawdown, Bechtel has had considerable success outplacing employees into its other operating companies and subsidiaries. Also, the Royal Commission direct-hired a significant number of former Bechtel employees at Jubail. These outplacement procedures cushioned the transition for many of its workers when their contracts expired.

4.4.5 MANAGEMENT COSTS

From the beginning of the Jubail program, the Royal Commission stressed keeping project costs down. It placed constant pressure on Bechtel to minimize its management costs. As major construction projects were completed, the Royal Commission severely cut Bechtel's management staffing authorizations to save money. This section examines the sources of Bechtel's contractual costs and their efforts to control them.

Under its management services contract with Bechtel, the Royal Commission paid all of the contractor's direct costs plus a percentage markup for overheads and a percentage fee. The contract had provisions for the fee to vary based on Bechtel's performance. Bechtel followed strict company accounting guidelines to document its costs. The Royal

Commission frequently audited these costs to validate them.

Bechtel's engineering and design charges equalled approximately 3% of the total project costs. Its construction management fee varied from 7% to 9% of direct construction costs during the life of the program. Generally, Bechtel achieved the lowest percentage markups during peak placement years while its highest percentages occurred during project planning and city management phases./58

The company's largest single expense was employee salaries and benefits. It was able to control these costs somewhat by using the international recruiting market. Bechtel kept its management costs competitive because it recruited labor from all over the world. Its large European contingent was less expensive than the Americans and its Filipino workers were even more cost effective, considering their skills. Ultimately, the Royal Commission was pleased with Bechtel's performance and felt it received excellent services for its investment in the Management Services Contractor.

4.5 PROJECT CONTROL

One of the most difficult aspects of project management is maintaining control and achieving progress simultaneously. One of Jubail's Program Managers said that it's easy to maintain control of a project but it often comes at the cost of stifling progress in a sea of bureaucracy. On the other hand, it's fairly simple to achieve progress at the cost of losing schedule and budget control. However, Bechtel managed to control the Jubail program year after year, yet it never deviated from its budget and schedule goals by more than a few percent.^{/59} How did the company control the program so effectively? In this portion of the case study I'll examine the systems that Bechtel developed to control costs and schedule on the Jubail program and determine how well they worked. I'll follow the control systems through contract-level to see how well they were applied. I'll study Bechtel's contract disputes history, its international contracting experience and its efforts to manage Jubail through the program's entire life cycle.

4.5.1 COST AND SCHEDULE CONTROL SYSTEMS

Bechtel adapted a proprietary budget and schedule control system from its Churchill Falls and James Bay projects to assist in managing Jubail at the program level. The system was automated, had a high-capacity data bank and could execute user commands quickly to provide an accurate, timely and useable product. Project Managers updated this

program and also used it as a management tool. At lower management levels, the system became more basic so that at the lowest (contract) level, control measures were manual.

Bechtel adapted its budget and schedule controls system to complement its program plans. Bechtel created an annual budget/schedule plan, a 5-year plan and a total project (10 to 12 year) plan. It performed a monthly review of planned versus actual progress on the annual plan. At the end of the year, Bechtel created a new annual plan that was approved by the client. The five year (with a quarterly level of detail) and total project plans (annual level of detail) were then adjusted based on the new annual plan. The annual plans were grouped by each project manager's scope of work. From there, project managers broke them down into facility detail and, finally, to individual contracts. Project Managers then updated and tracked budget and schedule at contract level./60

From the Program Manager's point of view, the key to schedule and budget control was to keep enough projects in the design - contract procurement - construction stages to maintain a steady flow of expenditures and construction progress over the long term. As a rule of thumb at Jubail during peak construction, the Program Manager preferred to keep commitments ahead of expenditures by about \$5 billion. When the gap closed to under \$3 billion, he knew there was a significant problem in either engineering or construction that had to be addressed./61 In most cases, he discovered that the engineering process was too slow and unable to keep

up with the progress made on construction projects. This was the program's biggest problem during the first year, when it fell way behind schedule. Too many engineering studies were performed and not enough detailed design work. After the new Program Manager identified the problem, his operational group managers and department managers redirected engineering efforts toward making design progress so that Bechtel could continue to get work under contract. Bechtel regained its schedule within a year by following this procedure and never fell behind again.

From the preceding, it's apparent that the principles the managers applied at Jubail had a greater impact on cost and schedule control than the type of computer system that Bechtel employed.

4.5.2 CONTRACTING

In this section, I'll examine the contracting issues which had the greatest impact on the Jubail program. The issues are: Bechtel's choice and use of different contract types; its methods for avoiding and settling contract claims and disputes; and its techniques for managing international contractors. I will concentrate on Bechtel's management of engineering and construction contracts.

Since it's not the subject of this study, I won't address service contracts in detail. However, I should point out that service contracting is an essential part of Jubail's city management. For example, Jubail obtains facilities

maintenance through service contracts. As facility construction slows in the coming years, service contracts may become the dominant form of contracting at Jubail. However, they're beyond the scope of this study since they generally don't apply to the construction program.

4.5.2.1 CONTRACT MANAGEMENT

For the most part, Bechtel used traditional forms of contracting to accomplish its engineering and construction tasks. The Saudis were enamored with fixed price contracting and wanted to use it for everything, including A/E contracts. This idea was inconceivable since there was no way for A/E firms to make accurate estimates of the work required to produce the detailed designs. Fixed price contracting would restrict the owner from making necessary changes to the design concept and from requesting additional products from the designers. After considerable efforts, Bechtel convinced the Royal Commission that Fixed Price A/E contracts wouldn't work.

Architect/Engineer firms won the majority of design work under Technical Services Contracts which typically contained unit prices for estimated man-hours, plus overheads and fees based on a percentage of direct labor costs. Bechtel controlled A/E contracts through two methods. First, it imposed a Bechtel engineering control system on A/Es who were new to the field and who hadn't developed their own. That way, the construction manager could monitor A/E efforts and

provide more assistance to those that needed it./62 Second, Bechtel established monthly coordination meetings involving key Project Construction Team members and A/E representatives for key contracts. In some cases, these meetings were held quarterly. They discussed key issues, such as interfacing, design progress and constructability./63

Most construction contracting was competitively bid Firm Fixed Price. In some cases, such as dredging and placement of hydraulic landfill, Bechtel used Fixed Unit Price contracts./64 However, Bechtel displayed the versatility to use less common contracting forms when the situation called for them.

The best example of Bechtel's use of alternative contracting involved the critical port construction activities that occurred early in the program. As I mentioned earlier, Bechtel received a directive with no notice to design and build the industrial and commercial ports within 26 months. Since the normal planning cycle (conceptual design, detailed design and formal bidding) took 2 to 3 years to complete before a construction contractor could begin work, it was clear that Bechtel had to use an accelerated procedure to meet its suspense date. It completed the conceptual design in-house and created a number of design-build (also known as Engineer-Procure-Construct or Fast Track) contracts to get the process moving. Although Bechtel viewed this type of contracting as more expensive and difficult to administer, it was the only way that Bechtel

could get the ports completed on time. It worked, as the ports came on-line in time to support industry and community development. Bechtel also used design-build contracts in a few cases when A/Es failed to perform on important contracts./65

Bechtel used some interesting techniques to increase its level of budget and schedule control through its construction contracts. The basic principle of its design and construction philosophy was that if schedule, construction methods, equipment and resources required were planned in conjunction with project designers, a practical design would result. If it followed this procedure, Bechtel would know ahead of time what it takes to build a project. The company institutionalized this process in its contract procurement procedures. In addition to performing its own cost estimate, Bechtel prepared a "Crewed Up Estimate" which detailed its view of the construction means and methods required to build the contract's scope of work. It required all bidders to provide their planned schedule, methods, equipment, resources and quality control plan in their bids. Bechtel then reviewed the lowest bids to determine whether the contractors had underestimated (or overestimated) the construction effort. Bechtel notified contractors who had apparently made mistakes and gave them the opportunity to retract their bids./66 This procedure helped insure that the contractor and construction manager agreed about the approach to construction before it began.

Another technique that helped Bechtel meet its budget and schedule goals while improving construction management was its policy of authorizing mobilization advances of up to 20% of the contract price for large contracts. The contractors needed the funding to build momentum early. This usually improved project performance. At the same time, it gave project managers an extra budgeting tool. If a project was underspent as it approached the end of the fiscal year, the project manager could expend mobilization advances to help reach the goal. In contrast, the project manager could withhold mobilization advances until the next fiscal year without affecting the work if the project was overspent.

Bechtel also used its contracts to reduce owner risk in materials procurement while maintaining a measure of control over it. The Royal Commission declined to procure any materials and equipment for its construction contractors. It wouldn't accept the risks inherent in an Owner Furnished Equipment program. It transferred procurement risks to its contractors. However, the contracts also required builders to use Bechtel's procurement control system. Contractors entered all major procurement actions into Bechtel's data bank. This allowed the construction managers access to updated procurement information on all contracts. Armed with this information, they could better influence contractor procurement activities./67

Under normal Bechtel contracting procedures, the construction manager performs quality control on its

contracts. However, Royal Commission preference and staffing limitations forced Bechtel to abandon its plan to perform quality control at Jubail. Instead, the company required its contractors to perform their own quality control while Bechtel handled quality assurance responsibilities. Under the terms of its contracts, the builders had to submit quality control plans for approval. The contractors also had to separate their quality control organizations from their operational chain of command to reduce the opportunities for conflicts of interest. Bechtel helped contractors who had no experience with quality control set up their programs and performed validation testing of its own through Technical Services Contracts./68 Despite Bechtel's initial uneasiness with its quality assurance role, its quality control plan was usually effective. The overall quality of construction at Jubail is excellent.

4.5.2.2 CONTRACT DISPUTES

The Jubail program had many elements which could have led to major claims and disputes. The program's tremendous scope could have led to serious design omissions and errors. Its tight timetable caused Bechtel to put some fixed price construction contracts out for bid based on 80% drawings./13 To compound the difficulty, its Saudi client established an unrealistic "no change order" policy at the beginning of the project. At the same time, Bechtel's Middle East contractors had "difficulty accepting the concept that contracts, once

signed, are not subject to continuing flexibility of interpretation." /70 Yet, despite the numerous factors that should have caused claims and disputes, Bechtel's claims experience on the Jubail program has been inconsequential. How did the company manage to avoid major contract disputes?

The answer appears to lie in three areas: (1) competent planning and contracting procedures; (2) cultivation of a "teamwork" concept; and (3) the realities of pursuing claims in Saudi Arabia. I've already introduced the first area in the preceding section. Bechtel's requirement for contractors to submit detailed descriptions of schedule, construction methods, equipment and resources not only helped the manager perform detailed bid evaluations but also eliminated the opportunity for future disputes over methods. Bechtel also established an effective prequalification procedure for construction contractors. Thus, it was able to eliminate many unqualified contractors prior to the starting the bidding process. In addition, Bechtel's emphasis on planning and design review assured production of the most complete and detailed contract documents possible.

The second area may be the most important, yet it's also the hardest to define. Bechtel cultivated a subtle feeling of "teamwork" among its contractors. The company often performed in the role of trainer for many of its first-time Saudi architect/engineers and construction contractors. Not only did Bechtel enforce the contract, it also assisted its contractors to make sure they followed its provisions. In

some cases, it found ways to keep the contractors afloat long enough for them to get organized. Bechtel also minimized contract terminations and didn't use liquidated damages clauses in its contracts./71 When disputes did arise, the company attempted to deal with them quickly, fairly and at the lowest organizational level possible./72 Contractors returned the good faith in kind. The international firms that performed the majority of design and construction during the early and peak program years were generally not claim oriented. In the words of a Deputy Program manager, "They were treated fairly, earned a fair profit, and did not wish to jeopardize their reputation or inclusion on future bid lists by submitting claims."/73

The third area was undoubtedly a major reason that contract disputes were minimized. There were two realities of pursuing contract disputes in Saudi Arabia. One, it would take a long time (upwards of 3 years) to go through the legal disputes process. Two, the ultimate resolution authority provided under the contract was the Saudi Grievance Board, which was comprised of religious officials. It had a reputation for ruling on the perceived intent of claims, rather than their legal bases./74 Bechtel didn't provide for alternative forms of dispute resolution in the contracts it prepared and administered on behalf of the Royal Commission. Thus, it's likely that many contractors who normally would have pursued disputes to the board were convinced not to because the time involved and uncertainty of the outcome.

Claims and disputes have become more common in recent years. This appears to be caused by several factors. Since major construction is complete, most of the contractors are inexperienced Saudis. They often enter losing contracts due to poor bid preparation and attempt to recoup losses through claims. They also tend to be unwilling to accept a consistent application of contract provisions. Finally, the Royal Commission has pressed for a conservative interpretation of contracts, often at the expense of contractors, due to a tightening budget.^{/75} Even though it has experienced more claims in recent years, Bechtel's total program disputes experience has been negligible. Over the program's life, it has averaged only one claim per three contracts and has settled half of them at 6.46% of the value claimed.^{/76}

4.5.2.3 MANAGEMENT OF INTERNATIONAL CONTRACTORS

Bechtel had to marshal resources from all over the world to plan and construct Jubail. American, European and fledgling Saudi firms won most of the Architect/Engineer contracts. Europe and Japan produced most of the major installed equipment. Many of Jubail's support industries produced bulk construction materials for the program. Korean and Turkish construction firms performed much of the civil work, Dutch contractors specialized in the dredging and port jobs, Japanese firms completed some of the most technical work and British and Americans won a few construction

contracts.

As the program matured, the Royal Commission began placing a great deal of emphasis on contracting with Saudi national construction firms to help build up their capabilities. According to a highly-placed Royal Commission official:

"The construction contract packages are planned with two ideas in mind: the value of each contract should be of the order of SR 50 million [\$15 million]; and the scope should be limited to as few disciplines, or specialties as possible. In this way it is hoped to encourage the development of the Saudi Arabian construction industry. Very large, multi-discipline contracts could only be undertaken by well-established international contractors." /77

In 1986 a Saudi law requiring that government contracts be awarded only to Saudi-owned firms began to affect Royal Commission contracts at Jubail. Generally, Saudi participation in the firms was only financial. However, Saudi involvement in financial management decisions created contract administration problems. It also discouraged some competent non-Saudi subcontractors from becoming involved. /78

Bechtel had great international diversity in its own management organization. Only about one-third of its employees were American. At least half of all employees were new to the Bechtel Group and were unfamiliar with its procedures. This mix could easily have created internal conflicts.

Given the variety of nationalities involved in all facets of the program, one would expect to see cultural clashes and conflicts generated from the participants'

different ways of doing business. As a rule, this didn't happen. What techniques did Bechtel use to manage its international contractors to avoid these problems?

Bechtel made effective use of contracting procedures to avoid creating problems with international contractors. For example, all contracts required key personnel to be functional in the English language. They also required all contractual correspondence to be in English. This ensured that all communication would be in the same language and reduced opportunities for misinterpretation.

Bechtel avoided significant disagreements over specifications by authorizing variations. It didn't establish a single specification standard for equipment and materials (such as American or European). Bechtel cross-referenced various international specifications and allowed substitutions liberally, provided they were thoroughly reviewed during the design/bid process. In some cases, Bechtel used entirely different specifications or established performance specifications to make materials produced by Jubail's own support industries competitive. These policies allowed contractors more flexibility in procuring materials and reduced disagreements over substitutions.

Bechtel also found that most of the major international contractors were familiar with its contract provisions and procedures. The contracts produced a common understanding of project requirements based on their general, special and technical provisions. This was not the case with new Saudi

firms, however. Many of them viewed contracts as loose agreements which could be interpreted flexibly./79 This produced a contract administration nightmare. Bechtel found itself in the role of trainer when dealing with these firms. It took an inordinate amount of effort to administer these contracts. However, Bechtel did it to support the Royal Commission's secondary objective of developing Saudi Arabia's construction industry.

Bechtel had to make some accommodations for the diverse nationalities that comprised contractor workforces. In all, 61 nationalities have occupied the Bechtel-built workers camp. It provided worker accommodations by leasing housing to construction contractors and providing support concession contracts for items such as food and health care. Bechtel discovered that food service was the most important area it could influence to keep the workers happy. It ensured that concessionaires operated multiple kitchens to provide the variety of foods that different ethnic groups required. It was a major administrative headache but Bechtel emphasized providing workers sufficient food of the right varieties to avoid agitating them./80 The fact that more than 51,000 workers over 14 years have worked at Jubail without any significant unrest attests to its success at meeting their needs.

4.5.3 LIFE CYCLE PROJECT MANAGEMENT

The Bechtel Group doesn't have a formal Life Cycle

Project Management program. However, it had to perform life cycle planning to be a successful management services contractor at Jubail. Bechtel's 20-year contract is one of the longest ever signed for its scope of work. The company had to plan based on long term performance goals encompassing the full scope of city planning, rather than focusing on short-term facilities completion dates. Bechtel not only planned and built facilities, it also maintained and modified them throughout its contract. Thus, it had to perform facility life cycle planning to avoid creating its own future problems. Its master plan alone consisted of 15 volumes, covering such topics as land use planning, urban design and growth management. This project truly represents the importance of project life cycle management.

Bechtel performed life cycle management primarily through the planning systems and organization it created. Bechtel's system of annual, 5-year and total project planning systematized the process throughout the program's life. The system forces short-term planning to be done in conjunction with long-term planning. Thus, the short-term effects of all projects are routinely measured against their long-term costs and benefits to the community.

The Jubail program organization may be unique in the world. From the beginning, it has been geared to support the city management concept. The organization has done this in two critical ways. First, it was created to tie city planning, private and public construction and city operations

together under a single manager. This amounts to more than being the Mayor of a city. The Program Manager's supporting organization is meshed together so that each department's plans and decisions are reviewed by the others before implementation. Representatives from each department form permanent planning teams for this purpose. This makes it far more likely that planners will develop project plans that take into account land use, environmental and societal issues as well as, design, construction, operations and maintenance issues. Second, Bechtel (and the Royal Commission) created a parallel organization which eventually became an integrated one. This concept provided not only for Saudization of the program but also for organizational continuity. Even though program managers rotate every few years, the systems and organization are in place to provide an accurate program history, short-term and long-term planning no matter who staffs the program. It's a well-designed organization that encompasses all aspects of managing a city into a single headquarters.

4.6 CASE SUMMARY

Saudi Arabian Bechtel Company, Limited managed the planning, design, construction and continuing development of Saudi Arabia's model industrial city. A regional publication described Jubail as, "a marriage of Islamic tradition with high technology and civil engineering."/81 Fourteen years after it began to master plan, Bechtel has seen 15 primary, 2 secondary and 64 support industries come on line. Twelve more primary, 10 secondary and 30 support industries are in some stage of active planning, design or construction. The city's industries employ more than 23,000 people and its total population exceeds 39,000 (50,000 during working hours)./82 Although the development of secondary industries has been somewhat disappointing, it's a function of Saudi demographics and economics rather than program management problems. Clearly, Bechtel's role in the Jubail development has been a success.

The purpose of this case study has been to determine the effectiveness of Bechtel's planning, organization, staffing and control efforts at Jubail. The company faced severe restrictions on its authority under the terms of its contract with the Royal Commission. However, it appears that Bechtel worked skillfully within those limits to be the program's driving force. I've reached several conclusions about Bechtel's management of this mega-project from the case research. They're listed below under the four applicable

management areas.

PLANNING

Strengths

1. Broke the huge program into manageable parts and planned at contract level to make best use of available staff.
2. Minimized amount of on-site construction. This expedited procurement and construction and improved quality control.
3. Effectively sequenced contracts to support the program schedule and minimize contract delays.
4. Planned to develop the industrial and community areas simultaneously and in phases. This way, industry and community kept pace and Bechtel avoided overdeveloping the city's infrastructure.

Weaknesses

1. Initially, failed to plan for phased city development to avoid overbuilding infrastructure.

ORGANIZATION

Strengths

1. Created a matrix organization with strong Project Manager control. Responsive to program needs.
2. Program Manager had complete control of the program within Bechtel Group. All staff and managers working on the project (except personnel) worked for him.
3. Program Manager delegated authority and responsibility to promote decentralized planning and control.
4. Separate reporting chains from the operations groups and functional departments provided the necessary checks and balances to the matrix.

Weaknesses

1. Initially failed to create an organization that could grow to keep pace with program requirements.

STAFFING

Strengths

1. Located complete management staff in Saudi Arabia. Made organization more responsive in a fast-paced planning, design and construction environment.
2. Recruitment of international staff saved money without significantly impacting the quality of the staff.
3. Able to draw specialized expertise from other Bechtel companies.

Weaknesses

1. Obtaining qualified staff required precedent setting pay and benefits packages which are difficult to cut back late in the program.
2. Locating the entire staff in Saudi Arabia created high turnover across the organization and difficulty in maintaining continuity.

CONTROL

Strengths

1. Concentrated on keeping commitments ahead of expenditures by several billion dollars so that there was always a steady flow of work from the design through the contracting to the construction phase.
2. Effective use of annual, 5-year and total project plan reviews to flag budget and schedule issues which needed to be addressed.
3. Tailored the type of contracting used to specific program requirements.
4. Requirements to submit methods, equipment and resource plans with bids helped Bechtel control the construction contract and reduce disputes.
5. "Teamwork" concept in managing contractors helped avert disputes.
6. Created a system to cross-reference international specifications that ensured procurement flexibility without reducing quality.
7. Accommodated workers' cultural preferences for food to avoid unrest.
8. Guaranteed life cycle program management by institutionalizing planning systems and program organization.

Weaknesses

1. Initially failed to control the engineering process to ensure that enough designs were completed to get construction work committed.
2. Requirement to contract with inexperienced Saudi firms has increased administration difficulties and disputes later in the program.

It's clear from this summary that Bechtel's management of the Jubail program has been a great success. However, it could easily have been a disaster. The firm got off to a poor start and lost control of the schedule during the first year. It failed to create a workable design process or an organization which could grow with the program. The Bechtel reaction to these early problems was just as significant. It took decisive action to replace the source of the problems and, within a few months, turned the entire program around. Bechtel has made all of its major milestones and stayed within its budget to the present day. This case clearly demonstrates the importance of proper planning, organization, staffing and control to successful international mega-project management.

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39. "Industrial Plan Shapes Up in Sand," p. 62.
40. Telephone interview with Anderson.
41. Interview with John N. Vanderschaaf, LTC USA, Retired (Current Bechtel Deputy Program Manager for Jubail), Al-Jubail, S.A., 21 Oct 1990, p. 1.
42. "The Construction Management Role in Project Implementation at Madinat Al-Jubail Al-Sinaiyah".
43. "Industrial Plan Shapes Up in Sand," p. 62.
44. "The Construction Management Role in Project Implementation at Madinat Al-Jubail Al-Sinaiyah".
45. Ibid.
46. Ibid.
47. Ibid.
48. Interview with Vanderschaaf, p. 1.
49. "The Construction Management Role in Project Implementation at Madinat Al-Jubail Al-Sinaiyah".
50. Interview with Vanderschaaf, p. 2.
51. Telephone interview with Anderson.
52. "Industrial Plan Shapes Up in Sand," p. 62.
53. Telephone interview with Perry Neubauer, President, The Architects Collaborative, Cambridge, MA, 7 Nov 1990.
54. Telephone interview with Anderson.
55. Ibid.
56. Ibid.
57. Interview with Vanderschaaf, p. 2.

58. Telephone interview with former Bechtel Program Manager
(Name withheld by request).
59. Telephone interview with Anderson.
60. Ibid.
61. Ibid.
62. Telephone interview with former Bechtel Program Manager
(Name withheld by request).
63. Telephone interview with Neubauer.
64. Interview with Vanderschaaf, p. 2.
65. Telephone interview with former Bechtel Program Manager
(Name withheld by request).
66. Telephone interview with Anderson.
67. Telephone interview with former Bechtel Program Manager
(Name withheld by request).
68. Telephone interview with Anderson.
69. Telephone interview with former Bechtel Program Manager
(Name withheld by request).
70. Interview with Vanderschaaf, p. 3.
71. Telephone interview with Anderson.
72. Interview with Vanderschaaf, p. 4.
73. Ibid., p. 3.
74. Telephone interview with Anderson.
75. Interview with Vanderschaaf, p. 4.
76. Various reports and documents from the Royal Commission
for Jubail and Yanbu (Identities withheld by
request).
77. "The Construction Management Role in Project
Implementation at Madinat Al-Jubail Al-Sinaiyah".
78. Interview with Vanderschaaf, p. 3.
79. Ibid., p. 3.
80. Telephone interview with Anderson.

Living in a Model Industrial City, Jan. 30, 1942

82. Various reports and documents from the Royal Commission
Hedut for Jubail and Yanbu (Identities withheld by
request).

show that the industrial zone is a model for the future of the country.

It is a model of the future of the country, and it is a model of the future of the world.

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CHAPTER 5 - COMPARISON OF USACE'S AND BECHTEL'S APPROACHES TO MEGA-PROJECT MANAGEMENT

I chose to perform case studies on the KKMC and Jubail projects for several reasons. Most important among them were that they were international mega-projects which involved the two largest construction management firms in the United States and they were constructed in the same country during the same general time period. I felt that the basic project similarities would allow me to control for some of the largest variables encountered in construction project case study design. However, as I performed research for the case studies I discovered many more similarities between the projects, as well as a large number of differences. Some of these involved circumstances (such as owner-manager relationships, project scopes and geographical peculiarities); others involved the firms' approaches to mega-project management. In this chapter, I'll identify these similarities and differences and use them as a basis for comparing USACE's and Bechtel's approaches to mega-project planning, organization, staffing and control.

5.1 CASE SIMILARITIES

Following is a list of the significant similarities between the two cases:

CIRCUMSTANCES

1. Both firms performed planning and control functions and contracted for the majority of engineering and design and all of the construction on their projects.

2. The clients for both USACE and Bechtel were Saudi Arabian government agencies.

3. Construction project sizes were similar. Jubail was an order of magnitude larger than KKMC, however both projects involved the construction of complete, self-contained and self-supporting cities.

4. Both KKMC and Jubail totally lacked an infrastructure at the beginning of the projects.

PLANNING

1. Both planned and built ports to support their operations.

2. Both planned and constructed camps for all construction workers to reduce mobilization time and support costs.

3. Both were responsible for developing programs to train their clients so that they could eventually take over responsibility for managing the projects.

ORGANIZATION AND STAFFING

1. Both offered similar, lucrative pay and benefits packages to attract large numbers of qualified managers quickly.

2. Both established matrix organizations; Bechtel's had stronger Project Manager control.

3. Both charged their clients design and engineering costs at 3% of project total and management services costs at 8-9% of direct construction costs.

CONTROL

1. Both used automated, proprietary control systems at project level.
2. Neither used automated control systems at contract level.
3. Both prequalified potential contractors prior to advertising for bids.
4. Both required construction contractors to perform their own quality control. Both performed quality assurance duties on behalf of their clients.
5. Both had an unofficial policy of working with marginal contractors and training them when necessary rather than terminating them.
6. Neither used alternate dispute resolution techniques. Both developed a "teamwork" concept to get the job done and minimize claims.
7. Both used very similar contract management procedures and techniques.

5.2 CASE DIFFERENCES

Following is a list of significant differences in project circumstances and in the way Bechtel and USACE approached project management:

CIRCUMSTANCES

1. USACE - Role at KKMC was to plan, design, build and leave.
Bechtel - Role at Jubail was to plan, design, build, operate and maintain.

2. USACE - Had almost total authority on the project under terms of the Engineer Assistance Agreement. Could commit funds, issue changes, settle disputes, select and terminate contractors. Saudi participation initially was limited. Later in the project the Saudis attempted to reduce USACE authority. They were unable to significantly reduce USACE authority but increased the amount of Saudi review.

Bechtel - Had little inherent authority under its Management Services Contract with the Royal Commission. Could direct the contractor as the Royal Commission's authorized representative. Saudis had the authority to make all decisions with Bechtel as primary advisor. The Royal Commission was totally integrated into the process from the beginning.

3. USACE - Had little interference from influence peddlers in Saudi Arabia because it was restricted by the Defense Acquisition Regulations. However, was impacted by Office of the Chief of Engineers interference during early dealings with Morrison Knudsen Saudi Arabia Consortium.

Bechtel - Saudi influence peddlers affected Bechtel. It had to deal with its own Saudi business partner (Suliman Olayan) as well as Saudi firms who wanted to do business with the Royal Commission. Was forced to contract with many Saudi firms that were unqualified. Followed Saudi Arabian contracting laws.

PLANNING

1. USACE - Used only US construction standards.
Bechtel - Used international construction standards.

2. USACE - City plan revolved around a concept of precast (at Al Batin) concrete facilities for standardization, quality control and economies of scale.

Bechtel - City plan concept was to maximize modular design and off-shore fabrication to minimize construction time and amount of work performed at Jubail.

3. USACE - Planned heavy use of Government Furnished Equipment, Materials and Services to minimize contractor risk, lower costs, speed mobilization and enhance quality control.

Bechtel - Provided virtually no Owner Furnished Equipment, Materials or Services (except mobilization camps) to minimize owner risk of claims and disputes. Used concession contracts to provide bulk materials.

4. USACE - Had no significant environmental issues to consider.

Bechtel - Had a number of environmental engineering design challenges. The plan minimized the project's adverse affects. However, Bechtel faced no organized opposition to development from environmental groups.

5. USACE - Selected almost all Architect/Engineer firms from the US.

Bechtel - Selected Architect/Engineer firms from all over the world.

6. USACE - Planned many of its construction contracts to be from \$100 to \$300 million with a 3-year construction duration to attract the best international firms.

Bechtel - Planned most of its construction contracts to be from \$10 to \$30 million to attract fledgling Saudi companies and develop the Kingdom's construction industry.

ORGANIZATION AND STAFFING

1. USACE - Placed as much of its organization in US as possible to reduce management costs.

Bechtel - Placed almost its entire organization in Saudi Arabia and at Jubail for better coordination and control.

2. USACE - Most members of the USACE organization were Americans who were previously employed in US government agencies.

Bechtel - Only about 1/3 of Bechtel's organization was American. About 1/3 were Canadians, Europeans or Australians. The final 1/3 were Filipinos. Later in the program Bechtel hired more Saudis.

3. USACE - Made several major organizational

changes during the life of the project (ex. Engineer Logistics Command took over Government Furnished Equipment Program half way through the project).

Bechtel - Maintained the same organizational thrust throughout the program. Changes were more of a natural evolution of the organization based on program requirements.

4. USACE - Had to follow US Civil Service hiring rules to build-up and displace its management staff.

Bechtel - Followed general industry hiring principles to obtain and release its management staff. It was not bound by US labor laws for workers employed in Saudi Arabia.

CONTROL

1. USACE - Used only Firm Fixed Price contracts and one huge (\$1 billion) Cost Plus Award Fee contract to perform construction.

Bechtel - Used mainly Firm Fixed Price construction contracts. Also used Fixed Unit Price and Design-Build contracts. Didn't use any Cost Plus contracts.

2. USACE - Ultimate dispute resolution authority was the Engineer Board of Contract Appeals in Washington, D.C.

Bechtel - Ultimate dispute resolution authority was the Saudi Grievance Board in Riyadh, S.A.

5.3 COMPARISON OF USACE AND BECHTEL MANAGEMENT

The preceding discussion established that, despite the similarities in circumstances at KKMC and Jubail, USACE and Bechtel Group didn't always take the same approach to project management. In this section, I'll compare some of the major management techniques used by these firms in their mega-projects and determine why some were more effective than others.

5.3.1 PLANNING

Both USACE and Bechtel exhibited significant strengths in project planning, particularly master planning. They approached master planning in slightly different ways but they were equally effective. For the most part, USACE performed centralized master planning at the Middle East Division Rear office in the United States. Bechtel performed master planning from its offices at Jubail and decentralized the process a little more. USACE centralized planning for two reasons. First, centralized planning and decentralized control has long been an American military imperative. It's an accepted and proven part of the USACE corporate culture. Second, USACE attempted to limit the size of its workforce in Saudi Arabia until construction began in order to hold down management costs. It was able to plan effectively from the United States because it hired American A/E firms and managed them through the Engineering Division in its Virginia office.

Bechtel, on the other hand, mobilized at Jubail as soon

as possible under Saudi requirements. The project was so large it split the job immediately into 10 or 12 projects with separate managers to plan Jubail in manageable pieces. As a result, Bechtel's planning had to be more decentralized than USACE's. Evidently, both approaches worked well because the master planning products were excellent and remained virtually intact throughout both projects.

Due to the size and complexity of the projects, as well as the difficult building conditions in Saudi Arabia, both companies incorporated time, cost and risk reducing elements into their plans. USACE planned a large Government Furnished Equipment, Materials and Services (GFE) program as part of its project plan. This program included government furnished precast concrete panels and structural members for all facilities. This program lowered construction contractor risk while increasing the owner's. It's believed to be responsible for many contractor bids that were lower than government estimates. Given the extreme environment, remote location and uncertain supply situation at the beginning of the project, this appears to have been a reasonable approach at KKMC.

Bechtel and its client were more risk-averse than USACE and insisted that contractors shoulder most of the risk. However, it too developed a plan to reduce construction costs while improving materials supply and quality. Bechtel planned to supply bulk construction materials through a system of on-site concessions. Although they weren't

officially supplied by the owner, Bechtel controlled materials costs by arranging for limited competition between concessionaires. Bechtel also reduced construction costs by planning a modular city, much of which could be prefabricated and shipped partially assembled to Jubail. This approach was also reasonable, considering the difficult environment and working conditions at Jubail.

USACE had planning shortcomings in two areas which Bechtel managed to avoid. Due primarily to the geographical separation of KKMC design and construction managers, USACE didn't perform an adequate amount of constructability planning during project design. As a result, KKMC experienced significant utilities interfacing problems at contract boundaries during construction. Also, there are so many different concrete panel designs that USACE lost much of the economy of scale and efficiency it hoped to gain by building a "precast city". These problems may have been avoidable if USACE had performed constructability reviews with its construction managers during detailed project planning.

For the most part, Bechtel managed to avoid similar contract interfacing and other constructability problems by involving construction managers more in the detailed project planning phase. It institutionalized constructability review by the construction managers during the planning process. In fact, the operating groups provided each project manager, even during the planning phase. Thus, it encouraged proper

review by having one manager responsible throughout the entire planning and construction process. On the other hand, USACE probably performed less-effective constructability reviews because it had separate project managers (also separated by an ocean) during the design and construction phases.

A less critical planning problem for USACE, but one which caused construction change orders, was a lack of cultural planning and Saudi involvement in design review. There were few Saudi liaisons located the United States to perform detailed design reviews with USACE. As a result, USACE produced some poor designs from a cultural perspective. Some of the designs were ultimately changed by owner directives after construction had started, causing increased project costs.

Bechtel generally avoided this difficulty because its organization fully integrated Saudis from the beginning. Also, the Royal Commission had more direct responsibility for design review under its contract with Bechtel. Thus, most cultural design problems were caught and corrected during design. I should note that, in both USACE's and Bechtel's circumstances, the Saudis often didn't really know what they wanted and performed only cursory design reviews even when they had the opportunity to participate. This was especially true early in both programs. Therefore, the Saudis often gave incorrect and contradictory directions when they participated in design reviews.

Both construction managers initially overlooked one other planning consideration that they had to recover from later. Although USACE planned to build KKMC in phases (First, Second and Third Brigade areas), it created only one schedule, based on a six-year construction plan. Consequently, as money for development tightened and the Saudi's cut planned expenditures on KKMC, USACE was initially unprepared to adjust its budget and schedule because it had no alternative plans. It recovered during construction by creating plans based on more realistic budgeting levels. Thus, it was able to make rapid and rational adjustments to budget and schedule when the owner changed project appropriations.

Bechtel's problem stemmed from a lack of phased planning early in the program. It fell behind schedule in the first year at Jubail because Bechtel planned to build infrastructure to support the city's projected 370,000 residents at once, even though it would be decades before the city really needed that much capacity. Bechtel couldn't complete designs on the huge facilities needed to support the entire population fast enough to get construction under contract. After the first year, Bechtel regained its schedule by planning to build the city in phases. It insured that each phase of the city would have the infrastructure required to support it. It designed and built a series of smaller facilities or large facilities built in stages but which were functional at each stage. Bechtel was then able

to produce designs with reduced scopes that kept construction commitments flowing.

5.3.2 ORGANIZATION AND STAFFING

As was the case in project planning, USACE and Bechtel organized and staffed effectively for their projects although they approached their tasks differently. They both established matrix organizations. However, Bechtel's organization had a greater level of Project Manager control than did USACE's. This difference was primarily due to locations of their respective staffs. USACE staffed most of its planning and engineering capability in the US while Bechtel's entire staff was in Saudi Arabia. During the early stages of the KKMC project, the Chief, Engineering Division at the Middle East Division Rear office in Virginia had greater control of the project than did the Project Manager (District Engineer), who was in Saudi Arabia. This arrangement was reasonable during project planning, although USACE suffered coordination problems due to split staff locations and responsibilities. When construction began, the Project Manager in Saudi Arabia took control of the project. He had a complete support organization on-site with the exception of design/engineering personnel. That element remained in the US and the Project Manager never controlled its efforts.

In contrast, Bechtel had virtually its entire program organization in Saudi Arabia and placed all responsibility

(and authority) for program completion on the Program Manager. Unlike the USACE Project Manager, Bechtel's Program Manager completely controlled planning, design, construction and operations at Jubail. His 10 Project Managers were the driving force of a strong matrix which coordinated decentralized planning and project execution. As the program progressed the organization evolved into different configurations, but Bechtel managed to avoid making radical changes to its structure.

As I mentioned before, both USACE's and Bechtel's organization and staffing plans were successful in the context of their projects. However, I prefer Bechtel's for two reasons. First, it established a clear chain of command (responsibility and authority) at all organizational levels which didn't change as program phases changed. It provided for a greater amount of continuity and a chain of responsibility (Life Cycle Project Management). Second, locating its entire staff in Saudi Arabia didn't appear to cost significantly more than USACE's split US-Saudi Arabian staff.

The primary reason for USACE's split staff was to lower its management costs by doing as much work in the US as possible. It was willing to accept a certain amount of organizational inefficiency in exchange for lower staffing costs. However, the decreased efficiency and duplication of effort that resulted from the split staff may have, in the long run, increased costs enough to offset savings. This may

be reflected by the fact that, despite USACE's cost control strategy, both firms cost their clients virtually the same percentage of construction costs for their services. It's impossible to make an accurate cost comparison, since government and private firm pricing policies and objectives are so different. It's probable that USACE's per-employee costs for managers in Saudi Arabia exceeded Bechtel's because of its huge fringe benefits package and government reemployment rights. Conversely, Bechtel charged its client a fee for profit that USACE didn't. Therefore, it's likely that USACE lost much of the cost advantage it gained by keeping staff in the US due to the management inefficiencies it caused.

A major advantage that both companies displayed during their projects was their depth of organizational talent. Although both USACE and Bechtel had to direct-hire a large number of managers, they were also able to staff most of their key management and engineering positions with home-grown talent. Both firms had considerable internal planning, operational and research capability. They mobilized it quickly for their mega-projects. This capability gives USACE and Bechtel a competitive advantage in the international mega-project management industry.

5.3.3 CONTROL

USACE and Bechtel mega-project management techniques were most comparable in the area of project control. At all

levels of the project, from program direction to contract management, the firms used similar control techniques. They were very successful in both projects. At program level, USACE and Bechtel employed large mainframe data banks and tracked schedule and budget using proprietary computer programs that had been adapted for the unique requirements of their mega-projects. At successively lower organizational levels, control techniques became less automated and more traditional. Control methods at the individual contract level were manual.

Detailed reports, statistics and data processing programs were essential at higher levels as tools to note schedule and budget trends and to flag potential problems. However, the most critical aspect of control for the Project Managers seemed to be their ability to break the projects down into simple components. The general principles they established and applied had greater impact on cost and schedule control than did the automated control systems.

USACE and Bechtel applied proven and institutionalized control systems at contract level. Their procedures were similar in most respects. They both required contractors to produce and follow detailed quality control plans and establish quality control chains of command that were separate from and parallel to the contractors' operational chains. They followed strict submittal and phased quality control planning systems. Field inspection and quality assurance testing by the construction manager were also key

components of quality control systems at KKMC and Jubail.

Neither used automated cost and schedule control systems at this level. They required contractors to develop their own schedules within the limits established by their contracts. Contract managers used the schedules to control construction progress. USACE required contractors to establish CPM networks for schedule control. It discovered that most of the international contractors weren't comfortable with this system at the contract level. Many of the CPMs were oppressively large (some had more than 20,000 activities). The unwieldy size of many of the CPMs and lack of contract-level automated systems to process them often rendered them useless as a control tool.

USACE and Bechtel both used monthly progress payment requests, advance payments, and retainage to control contract costs effectively.

USACE and Bechtel also used similar control systems to avoid contract disputes and promote cooperation. Instead of concentrating on creating detailed alternative dispute resolution procedures, they attempted to control disputes by avoiding them. They produced high quality, detailed drawings and explicit contract documents to reduce the number of possible ambiguities. USACE and Bechtel prequalified contractors to insure that those who bid were capable builders. They cultivated an unofficial spirit of "teamwork" by working to help contractors get their own control systems in place. In addition, they minimized contract

terminations. Both firms also decentralized dispute resolution authority to the lowest possible level. This combination of measures helped reduce conflicts and resolve most that occurred before they required official Contracting Officer Decisions.

Although the procedures that USACE and Bechtel followed and the "teamwork" atmosphere they created definitely reduced their project disputes history, I don't want to overestimate their success. Much of the credit for the small number of disputes is probably due to contractor reluctance to become involved in them. Most of the international firms hoped for more contracts in Saudi Arabia and feared losing future ones if they got a reputation for being "claims oriented". Also, many contractors avoided taking disputes to the Saudi Dispute Resolution Board (Bechtel) and the Engineer Board of Contract Appeals (USACE). Bechtel's contractors were skeptical of the Saudi board's religious influence and USACE's faced an expensive, time-consuming process when they dealt with the Engineer board. Because of these outside factors, it may be more coincidental than by design that USACE and Bechtel avoided a large number of disputes.

USACE and Bechtel preferred Firm Fixed Price construction contracts but both of them used other forms when required. USACE created a \$1.2 billion Cost Plus Award Fee (CPAF) contract for construction support services at KKMC. Bechtel used several Engineer-Procure-Construct (EPC) contracts for port building at Jubail. Neither firm has used

these types of contracts often. Both found them difficult to administer, partly because of their lack of familiarity with the contract types. USACE's CPAF contract was ultimately the biggest disappointment of the KKMC project. Severe owner pressure forced it to switch to Firm Fixed Price construction support contracts halfway through project execution. USACE's failure was in control rather than concept. It failed to establish an adequate contract administration organization or schedule and budget controls for this type of contract. USACE attempted to control a flexible type of contract with a Firm Fixed Price system and got burned.

Bechtel's experience with its EPC contracts was better. The port construction contracts actually helped Bechtel regain a year on its schedule after it had fallen behind early in the Jubail program. However, even after its good experience, Bechtel didn't become a convert to EPC contracts. It still feels that EPC contracts generally cost too much and are too difficult to administer to warrant their use in standard contracting situations.

5.4 SUMMARY

The KKMC and Jubail case studies were examinations of the way a public (USACE) and private (Bechtel) construction management firm planned, organized, staffed and controlled two international mega-projects. I discovered that USACE and Bechtel followed the same general principles in virtually all aspects of project management. Although many of their specific management techniques were different, USACE and Bechtel based them on similar thought processes. Their management techniques were both very successful.

The following summarizes key elements of USACE's and Bechtel's combined management performance during the KKMC and Jubail mega-projects.

PLANNING

- Both centralized and decentralized master planning techniques were effective.

- Contingency planning, especially for changes in funding levels, had to be performed in conjunction with the master plan.

- Projects had to be broken down into understandable, self-contained components for planning.

- Designs that standardized construction elements (modular, pre-fabricated or precast facilities) sped construction, lowered costs and enhanced quality control.

- Constructability and contract interfacing review were essential parts of the detailed design process.

- They had to plan and build supporting infrastructure in conjunction with the projects.

ORGANIZATION AND STAFFING

- Matrix organizations were effective during the project planning, design and execution phases.

- Strong Project Manager control of the matrix helped focus functional efforts in the fast-paced mega-projects.

- Costs saved by locating staff off-site may have been neutralized by increased costs from lowered management efficiency.

- Both firms staffed most of their key project management positions from within without decimating their other operating companies.

CONTROL

- The ability to spend large sums of money consistently (by keeping design progress ahead of contracting) was a key to project completion.

- They attracted good international builders by adjusting contract scopes and lengths, limiting risk by providing services and easing supply problems by building dedicated port facilities.

- Learned to accommodate cultural differences of clients, A/Es, and contractors into planning and contracts to enhance project control.

- Reduced the anticipated number of disputes through prequalification, good planning, fair treatment, management assistance, as well as the uncertainty of claims resolution in a foreign legal system.

- Standard operating procedures for contract control were effective in the mega-projects.

- Use of unfamiliar contract types required greater planning and contract control efforts.

CHAPTER 6 - CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

6.1 CONCLUSIONS

It's time to return to the central problem and focus of this thesis. The goal of this study is to determine techniques construction managers can use to effectively plan, organize, staff and control international mega-projects. In Chapter 1, I posed 10 questions that I intended to address in this paper. In this section, I'll restate those questions and answer them in the form of conclusions drawn from multiple case studies of the KKMC and Jubail mega-projects:

1. What organizational forms are effective for a construction manager to use in international mega-projects? At what levels within the organization should responsibilities and authority be assigned?

Conclusion

From the KKMC and Jubail case studies, I'm convinced that the most appropriate organization for international mega-projects is a matrix with strong Project Manager control over functions. The large scope, tight timetable and budget of mega-projects necessitate a greater level of operational control over specialized functions than is common on smaller projects.

It's critical to the success of international mega-projects that responsibilities and authority be assigned to facilitate decentralized project control. Planning can be either centralized or decentralized. The Project Manager must have virtually complete authority and responsibility since international mega-projects are often far-removed from the construction management firm's home office. The fast-paced nature of mega-projects requires an on-site manager with the experience and authority to make crucial decisions. Lower level managers within the project framework must also be given a great deal of responsibility and authority to avoid decision gridlock, which can result from centralized project control. In all cases, authority must match responsibility.

2. What personnel policies can be used to attract the right people with the right skills to the project at the right time, and to support them during demobilization?

Conclusion

Lucrative pay and benefits packages are essential to attract qualified engineers and managers to remote job sites. However, firms should keep in mind when developing the packages that they will have to start downsizing the workforce just after reaching the construction peak. If the benefits are too good or the contracts too long, the firm will set precedents that are difficult to change when it needs to cut back. As a result, it may be better to offer higher pay with fewer fringe benefits and shorter contract lengths (although this may create continuity problems).

Another possibility is to create packages with increasing benefits for those who serve beyond the standard contract length but with decreasing benefits if they serve beyond the target length. In any case, personnel recruitment and outplacement planning must be conducted in conjunction with project planning to ensure that personnel policies support the construction plan.

3. What are the logical physical locations for the construction management staff?

Conclusion

Generally, I conclude that the entire construction management staff should be located as close to the project site as possible. Long-term efficiency and coordination concerns should overshadow the shorter-term management cost savings plans that influence decisions to staff elsewhere.

4. How can construction managers adequately staff projects while controlling management costs?

Conclusion

Owners and, therefore, construction managers often worry too much about management costs early in the project. Construction management firms must mobilize quickly to get planning and procedures established and to get key management personnel involved, even if their primary responsibilities come later. The top-level organizational shell should be the first thing established and the last thing dismantled. I believe that spending extra management money up front will reduce the amount needed later because it should produce better planning and execution. Also, owners may be able to

control management costs by linking construction management firm compensation to efficiency. Instead of paying construction managers a percentage of direct construction costs, owners may base pay on a variety of other factors which may better reflect construction manager efforts. Some alternatives are: (1) Declining percentage fee based on a direct construction man hour scale; (2) Fixed fee for a given range of direct man hours; and (3) target direct costs with incentives for completing under budget and ahead of schedule. Of course, the construction manager contract would have to provide for adjustments due to owner-directed scope changes. These procedures may relieve the (sometimes) perverse incentive of the cost-plus system, where increased project direct costs result in increased payments to the construction manager.

5. What construction contract types are the most appropriate for use in international mega-projects?

Conclusion

No single contract type stands out as the best to use in international mega-projects. However, it appears there can be a place for each of the recognized contract types under appropriate circumstances. USACE and Bechtel demonstrated that Firm Fixed Price construction contracts based on the lowest responsible bid can be used successfully even in fast-paced international mega-projects. Cost-plus contracts also have a place, as do design-build/fast track contracts.

The key point is that each contracting type can be applied to international mega-projects if they're used under the circumstances for which they were designed.

6. What special management techniques are effective for controlling international contractors?

Conclusion

An often overlooked facet of dealing with international contractors is that many (probably most) of them aren't familiar with American contracting techniques or construction standards. Also, they may not be familiar with the laws and procedures of the country they will be working in. To compound the problem, their workforce may be comprised of different nationalities than their own. It's difficult to control this blend of nationalities, cultures and business practices using standard procedures.

Managers must take into account the cultural differences of the owner, contractors and workforce

when planning international mega-projects. If American standards and procedures are to be used, a training program to familiarize foreign contractors may help avert problems during the construction phase. If different standards and procedures are used, the construction manager will have to train its own staff. The construction manager must ensure that the different needs (housing, food, recreation, etc.) of an international workforce are met. There are two salient points here: (1) Construction managers who simply expect international contractors to be ready to comply with American standards and procedures will discover the fallacy during construction, when it's most expensive to correct. (2) Procedural and cultural differences in owners, contractors and workers must be identified and addressed during the master planning and detailed design phases.

7. How can construction managers minimize contract disputes?

Conclusion

First, the prequalification process is important. The process allows construction managers to identify and eliminate marginal contractors before the bidding process begins. The remaining contractors tend to be more professional and usually less claims oriented than marginal contractors. Second, it's essential to decentralize authority to promote informal dispute resolution at the contract manager level.

Third, mega-projects provide a unique opportunity to get away from a traditional adversarial construction manager - contractor relationship and build a feeling of teamwork. It's difficult to terminate poorly performing contractors during mega-projects because the completion of one contract often impacts the progress of others. Thus, there's a greater need for construction managers to work with contractors who are having trouble, rather than simply administering their contracts.

The case studies didn't validate ADR techniques as a requirement to minimize court actions on international mega-projects. ADR techniques are probably more applicable to projects in the US because American owners and contractors appear to be more litigious than their international counterparts.

8. Does a Life Cycle Project Management (LCPM) philosophy apply to mega-projects?

Conclusion

LCPM is probably more important to mega-project management than it is to smaller projects. Primarily, this involves doing two things: (1) Establishing an organization which can take a project through all of its phases. The same personnel that start a project don't necessarily need to finish it. However, positions should evolve so responsibility and authority can be traced throughout the life of the project.

(2) Establishing a way of doing business that is institutionalized and followed. This provides the project a permanent set of standard procedures to complement a steady organization.

Mega-project management requires a greater level of continuing organizational knowledge and responsibility than smaller projects. Their long duration insures that many of the facilities the construction manager produces will be in operation before the project is completed. As a result, the construction manager has a personal (as well as professional) stake in facility performance, operation and maintenance. Therefore, the Project Manager at the end of a program must be able to determine why a facility designed seven years earlier was built the way it was. There has to be a clear record of decisions and accountability. This is the essence of LCPM.

9. How many construction support services should construction managers provide their contractors?

Conclusion

In remote areas, it may save contract costs and time to provide a number of services to contractors that they would normally provide for themselves. Some of the possibilities include contractor mobilization camps, food and facilities, bulk construction materials, installed equipment, construction equipment, materials handling and transportation. However, each service an owner provides through its construction manager increases owner risk.

For owners who are risk-averse, concession contracting with service providers may have the same effect without requiring the owners to accept the risks associated with owner provided services. If properly administered, concessions are an excellent alternative to owner provided services.

In developed areas, it may be inappropriate for owners to provide any services to their contractors due to their local availability.

10. How do construction managers plan for infrastructure

development in conjunction with completing mega-projects?

Conclusion

An aspect of many international mega-projects is that they are executed in areas which lack a supporting infrastructure. Planners must consider how the project is to be built, not only what will be built. They must include infrastructure requirements in schedule and cost planning, such as: (1) moving, housing, feeding and caring for thousands of construction workers living away from the project site; and (2) providing electric power, water, sewerage, roads, transportation and communications to support the construction effort.

This requires planners to examine construction in view of project support needs. They must reorient the priorities of these items to allow them to be designed, purchased and completed early to support construction.

6.2 LIMITATIONS OF RESEARCH

I'm satisfied that the multiple exploratory case study methodology I used for the KKMC and Jubail projects was appropriate to accomplish my research objectives. I'm confident that the ten conclusions in the preceding section are applicable to current and future international mega-projects. However, my research was limited by the factors listed below:

1. Both mega-projects were performed for government agencies. Mega-projects constructed for private firms or consortiums could be driven by different factors than those performed by government agencies, which tend to be less cost-sensitive.
2. I had sufficient access to USACE records and personnel to analyze the case from both the project and individual contract levels. In Bechtel's case, I had little access to company or Royal Commission documents. Also, all of my interview subjects viewed Jubail from the program perspective. I was unable to obtain contract-level insights which may have exposed additional strengths and weaknesses on the Jubail project.
3. Neither project was significantly impacted by two factors which are becoming commonplace in other large projects. The missing factors were: (1) Organized environmental opposition; (2) Requirements for innovative financing. The importance of dealing with these factors during the master planning process shouldn't be underestimated but I couldn't examine them in this thesis.

Although these research limitations don't diminish my confidence in the conclusions of this thesis, they do indicate the need for further research in this field.

6.3 RECOMMENDATIONS FOR FURTHER RESEARCH

Although many aspects of mega-project management are identical to those for smaller projects, there are also many differences. Therefore, mega-projects deserve a separate body of research to determine ways to improve their management. I chose to research international mega-projects using an exploratory multiple case study methodology. I'm satisfied that I accomplished my original research objectives. Still, this study barely scratches the surface of mega-project management research opportunities. The following are recommended areas of more focused research for those with an interest in mega-project management:

1. Construction management of mega-projects for private companies.
2. Planning, engineering and constructing mega-projects in an environmentally sensitive world.
3. The application of innovative financing techniques to mega-projects.
4. Planning infrastructure to support mega-projects.
5. Impact of construction technology on mega-projects.
6. In-depth research into any of the following aspects of mega-project management:
 - a. Master planning.
 - b. Management of detailed design.
 - c. Mega-project schedule and cost control methods.
 - d. Organizing and staffing for mega-projects.
 - e. Dispute resolution techniques for mega-projects.
 - f. Planning and managing contract interfacing.
 - g. Management of international contractors.

APPENDIX A KKMC CONSTRUCTION CONTRACT SUMMARY/1

CONTRACT #	FACILITIES	PRIME CONTRACTOR	FINAL K AMOUNT	START DATE	SCHED COMPL	CHARGES & CLAIMS
75-76-C-0018	Test Wells	Ibrahim Abumniyan Organization	\$9.394M	Oct 75	Oct 78	??
75-76-C-0065	Construction Wells	Compagnie Mediterranee Di Prospezioni	\$14.353M	??	??	??
76-76-C-0001	Port at Ras Al Mish'ab	Santa Fe Overseas, Inc.	\$218.000M	29 Jul 76	01 May 81	??
76-79-C-0001	Gas Turbine Generators	Westinghouse	\$63.684M	08 Jan 79	14 Nov 82	26
78-82-C-0263	KKMC Telecommunications & Construction of 1st Bde Area	Telefonaktiebolaget	??	??	??	??
86-77-C-0091	KKMC Support Services	Morrison-Knudsen Saudi Arabia Consort.	\$1.076M	26 Jul 77	20 Feb 81	N/A
86-77-R-0094	Advance Support Family Housing Phase I	Laing-Wimpey Alireza, Ltd.	\$27.815M	??	??	??
87-79-C-0064	Self Contained Living Units - Workers Community Phase II	Atlantic International Marketing Corp.	\$20.275M	11 May 79	29 Nov 80	32
93-78-C-0001	Family Housing KKMC, Al Batin	Laing-Wimpey Alireza, Ltd.	\$28.059M	16 Jan 78	26 Apr 79	21
93-79-C-0001	Areas 1&3 Family Housing	AlHuseini-ADA	\$207.750M	16 Sep 79	19 Dec 82	77
93-79-C-0002	Chilled Water Plant Area, 19A	Hyundai Engineering & Construction Co.	\$64.692M	05 Jul 79	22 Oct 82	40
93-79-C-0003	Switchyard & Substation, 19E	Deelim Industrial Company, Ltd.	\$28.112M	03 Jul 79	15 Oct 82	54
93-79-C-0004	Runway, Taxiway & Cargo Fac.	Dellauro-Shawyer	\$14.635M	08 Jul 79	12 Jul 81	22
93-79-C-0005	Troop Facilities, 10 & 10P	Saudi Building Technical Gen. Cont. Co	\$104.545M	26 Sep 79	28 Feb 83	72
93-79-C-0006	Sewage Treatment Plant, 20	Dellauro-Shawyer	\$25.113M	29 Oct 79	28 Dec 81	35
93-80-C-0001	Fuel Facilities Area 19F	Saudi Arabian Development Co./ Kier International, Ltd.	\$35.158M	01 Mar 80	06 May 82	60
93-80-C-0002	Sitework & Utilities Site B	Dong Ah Const. Ind'tl Company, Ltd.	\$38.045M	29 Mar 80	30 Sep 82	71
93-80-C-0003	Plant Nursery	EID Establishment	\$3.303M	01 Apr 80	03 Mar 83	11
93-80-C-0004	Well Water Collection System	Kuk Dong Construction Company, Ltd.	\$28.050M	10 Mar 80	30 Sep 82	37
93-80-C-0005	Site Management/Life Support Services	Saudi Maintenance Company, Ltd.	\$128.661M	03 Jun 80	13 May 83	48

CONTRACT #	FACILITIES	PRIME CONTRACTOR	FINAL K AMOUNT	START DATE	SCHED COMPL	CHANGES & CLAIMS
93-80-C-0006	Service to Operate & Maintain IBM 370/158 Computers	Saudi Computer Services/Statskonsult International AB	\$33.081M	06 Jul 80	05 Oct 83	13
93-80-C-0007	Construction Support Services	Sam Wihan Corporation	\$272.663M	23 Jun 80	09 Jun 83	52
93-80-C-0008	Areas 8812, Family & Ind'l Facilities Phase I	General Agencies Corporation/ Sam Wihan	\$141.315M	18 Aug 80	23 Jul 83	41
93-80-C-0009	Wastewater Treatment Plant, 21	Development International Trade Co.	\$11.522M	20 Oct 80	29 Mar 83	27
93-81-C-0001	Ancillary Facilities Items 1-3	Al Huseini-ADA	\$4.632M	02 Sep 80	20 Jun 83	16
93-81-C-0002	Troop Facilities Area 9	Chin Hung International, Inc.	\$139.726M	06 May 81	10 May 84	30
93-81-C-0004	Ancillary Facilities Items 4-6	Daelim Industrial Company, Ltd.	\$15.063M	09 Jul 81	02 Sep 82	44
93-81-C-0006	Areas 285, Family Housing	Al Huseini-ADA	\$226.258M	28 Sep 81	08 Oct 84	15
93-81-C-0007	Hospital Area 15H	Kuk Dong Const. Co./Al Mashrik	\$164.836M	10 Nov 81	08 Mar 85	10
93-81-C-0008	Support Paving & Sitework	Saleh & Abdulaziz Abahsein Company	\$7.471M	15 Nov 81	20 Nov 82	12
93-81-C-0010	Centrum Area 13	You One Construction Company	\$330.085M	18 Nov 81	26 Feb 86	16
93-81-C-0011	Ammo Storage Fac. & Firing Rng	Lotte Construction Company, Ltd.	\$63.956M	23 Nov 81	26 Oct 84	9
93-82-C-0001	Family Housing Area 4, Support Facilities Area 15S	Sam Wihan/Keong Nam Enterprises, Ltd.	\$154.542M	03 Feb 82	02 Jan 85	17
93-82-C-0002	Central Plant Control System, 2	Honeywell-Turki Arabia	\$29.945M	14 Dec 81	10 Jul 86	5
93-82-C-0003	Crude Oil Facility Area 19G	Chon/Shinhan Engineering & Const. Co.	\$12.221M	30 Mar 82	20 Dec 83	2
93-82-C-0004	Womens' Clinic Addition & Miscellaneous Construction	Almusaadiah-Pepper Company, Ltd.	\$4.503M	12 Apr 82	03 Mar 83	1
93-82-C-0005	Engineer Center & School	Obeid & Al Mulla Construction Co., Ltd	\$92.984M	26 Jun 82	08 Jun 85	1
93-82-C-0006	Areas 8812 Family Housing & Industrial Facilities Phase II	Sam Wihan Corporation	\$225.188M	22 Jun 82	23 Jan 86	3

1. Compiled primarily from USACE reports on active construction contracts during 1983. Since construction actually continued until 1988, contract amounts, completion dates and number of changes and claims for contracts completed after 1983 are not final figures. "Al Batiri District Active Contracts Status Report," USACE, 1 Sep 1982. Also, "Contracts Assigned to Hospital Resident Office - HREC-NA," USACE, Undated.

APPENDIX B KKMC ARCHITECT/ENGINEER KEY CONTRACT SUMMARY/1

CONTRACT #	FACILITIES	PRIME CONTRACTOR
75-74-C-0027	KKMC Master Plan	Brown, Daltas & Associates
75-76-C-0045	KKMC Engineer Center	Reynolds, Smith & Hills
75-76-C-0047	Airfield	Burns & McDonnell
75-76-C-0055	KKMC Design	Brown, Daltas & Associates/Sippican Consultants, International
75-76-C-0062	Engineering Support Services	Burns & Roe Industrial Services Corporation
78-77-C-0052	KKMC Hospital	Stone, Marraccini & Patterson/Bently
78-77-C-0064	KKMC Schools	Earl R. Flansburgh & Associates/Anderson-Nichols/R. S. McMillan (JV)
78-78-C-0051	Telecommunications System	Teleconsult, Incorporated

1. Compiled by the author from various source documents at USACE Historical Office, The Kingman Building, FT Belvoir, VA on 6 May 1990. This is not intended to be an all-inclusive listing of A/E contracts but it identifies the most significant ones during the KKMC project.

GLOSSARY OF TERMS

ACO - Administrative Contracting Officer. USACE term referring to the delegation of specified authority to another by a procuring contracting officer.

ADR - Alternate Dispute Resolution. Techniques used to resolve contract disputes without resorting to litigation.

Arabian Bechtel Company, Limited - Later, Saudi Arabian Bechtel Company. Bechtel Group's operating company (with Saudi partner) that signed a 20-year Management Services Contract with the "Royal Commission for the Development of Jubail and Yanbu" to manage the Jubail program.

ARAMCO - Arabian-American Oil Company.

CONUS - Continental United States.

CPAF - Cost Plus Award Fee. USACE term for a contract which reimburses the contractor for its expenses plus a fee for profit. The fee is either an agreed amount or a percentage of total reimbursable expenses.

CS-Squared - Cost Schedule Control System Criteria. A set of cost and schedule tracking criteria prescribed by DAR for cost-reimbursable jobs and required by the contract with MKSAC. MKSAC was to create a management system that met the criteria to control procurement costs and schedule.

DAR - Defense Acquisition Regulation. Regulation governing all procurement and construction performed by DOD agencies. Replaced in 1984 by the Federal Acquisition Regulation (FAR), which standardized contracting procedures for all Federal agencies.

DCAA - Defense Contract Audit Agency. Audited MKSAC's records for the CPAF contract at KJMC.

DOD - Department of Defense.

EAA - Engineer Assistance Agreement. Country to country agreement between the United States and the Kingdom of Saudi Arabia, signed in 1965. Agreement which defined USACE's involvement in the Saudi Arabian construction program.

ELC - Engineer Logistics Command, MED. District-level command of MED created to control life support contracts and GFP.

EPC - Engineering-Procurement-Construction. Bechtel term for design-build and fast track contracts.

EPLO - Engineering Planning and Liaison Office.

FMSA - Foreign Military Sales Act. Enacted into law in 1968 (Public Law 90-629) and modified 6 times; governs sale of US military equipment and construction services to foreign countries.

GDMW - General Directorate of Military Works. MODA's construction management branch.

GFP - Government Furnished Property. Property, equipment or materials provided to contractors by USACE. The term can also be used to refer to Government Provided Services to construction contractors.

KKMC - King Khalid Military City. A military complex for 50,000 people designed and built by USACE to accommodate two Saudi Arabian armored brigades near Wadi Al Batin, S.A.

LNG - Liquid Natural Gas. A useful byproduct of oil extraction that is the basis for both power and feedstock at Jubail Industrial City.

MEAPO - Middle East/Africa Projects Office, USACE. Formed as a District-level element of the South Atlantic Division from remnants of the MED. Responsible for close out management of Saudi projects for USACE.

MED - Middle East Division, USACE. Organization established in 1976 to provide full service construction management for all USACE construction projects in the Middle East. Reorganized as MEAPO in 1986.

MED (Forward) - That portion of the Middle East Division, USACE located in Saudi Arabia. Headquartered in Riyadh, with primary responsibility for construction management.

MED (Rear) - That portion of the Middle East Division, USACE located in the United States. Headquartered in Berryville, VA with primary responsibility for administering A/E contracts.

MKSAC - Morrison-Knudsen Saudi Arabia Consortium. Group of contractors awarded a \$1.2 billion CPAF contract for construction and support services at KKMC.

MODA - Saudi Arabian Ministry of Defense and Aviation. Client of USACE and owner of KKMC.

OCE - Office of the Chief of Engineers, in Washington, D.C.

OFE - Owner Furnished Equipment. Private industry term meaning equipment and materials provided by the owner to construction contractors. Equivalent to "GFP" in public

contracting.

O&M - Operation and maintenance.

PETROMIN - Ministry of Petroleum and Mineral Resources, arm of the Saudi Arabian government responsible for development of oil processing industries.

RFP - Request for Proposal. Request to a potential bidder for a contract proposal. Also a request to a contractor for a proposed cost and time adjustment to an existing contract resulting from a change order.

Royal Commission - Royal Commission for the Development of Jubail and Yanbu. Created by the Saudi government to avert bureaucratic delays to development of the new industrial cities at Jubail and Yanbu. It has both planning and governing authority in the project areas.

SABIC - Saudi Arabian Basic Industries Corporation, arm of the Saudi Arabian government responsible for development of industries not related to oil processing.

SCECO - Saudi Consolidated Electric Company, government run company responsible for providing electric power to the Kingdom.

SOP - Standard Operating Procedures. Established, written procedures to be followed within an organization.

USACE - United States Army Corps of Engineers.

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